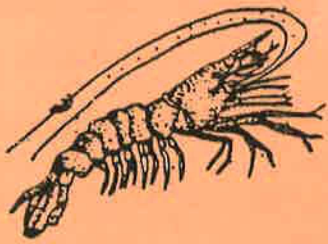
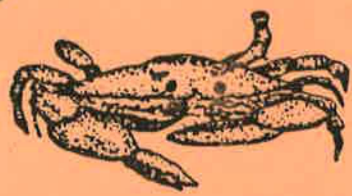
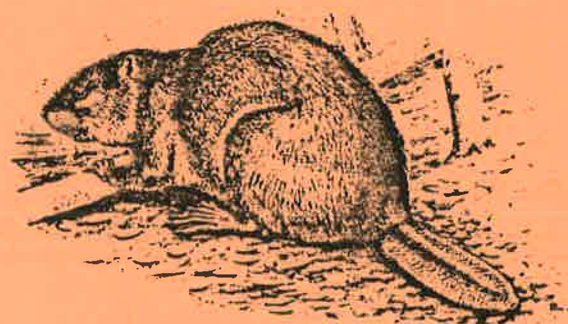
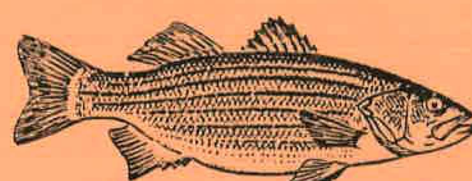
541





Natural Resource Inventory
Apalachicola-Chattahoochee-Flint River Basin





U.S. Department of Interior
Fish and Wildlife Service
Division of Ecological Services

November 18, 1980

ERRATA

The following errors in the Atlas of North American Freshwater Fishes have been brought to our attention:

Page	
iii	Louis Lemicux should appear as Louis Lemieux, Director, National Museum of Natural Science, Canada.
vii	Line 15 - National Museum of Canada should appear as National Museums of Canada. Jadniga Aniskowicz should appear as Jadwiga Aniskowicz.
ix	Michèle Stergerwald should appear as Michèle Steigerwald.
9	The last sentence should read - date and title, with complete citations appearing in Appendix A (837-848).
22	*Lampetra alaskanse* should appear as *Lampetra alaskense*. Line 4 of systematics - *japonicum* should appear as *japonica*.
41	The period has been deleted in the map caption after the *o (oxyrhynchus)* for *A. o. desotoi*.
55	The reference to Thompson et. al. 1979. in the biology section should read (Thomson et al. 1979. Reef Fishes of the Gulf of California).
63	The reference to Cross 1975 in the distribution and habitat section should read (Cross and Huggins 1975. Copeia:382-85).
74	Insert the word order in line 7 of the systematics section, thus reading: "present order following...."
75	MT in line 9 of the distribution and habitat section should be MB, indicating Manitoba instead of Montana.
167	Line 5 of systematics - specific destination should appear as specific distinction.
197	Delete the second period after *n..* in the map caption.
224	Delete the parentheses around Hubbs and Greene. They originally described the species in the genus *Notropis*.
271	The common name for *Notropis heterodon* is the Blackchin shiner, not Blacknose shiner.
311	Under adult size - attains should appear as Attains.
353	In the illustration caption Alleganey Co., should be Allegany Co.

369 The illustration caption should not read (NCSM) but instead read MO:Jefferson Co., Big River at Byrnes Mill, 234 mm SL (Mo. Dept. Cons.).

425 In the illustration caption Harbersham should be Habersham.

499 Line 1 of type locality - Oxbox should appear as Oxbow.

506 *Empetrichthys merriami* is considered extinct.

512 The hollow dot in southeastern North Carolina should be solid, indicating a record for *Fundulus pulvereus*.

521 The reference to Thomerson 1966. Tulane Stud. Zool. Bot. 13:29-47) should read Thomerson 1966. Tulane Stud. Zool. 13:29-47).

525 The hollow dot in southeastern North Carolina should be solid, indicating a record for *Fundulus pulvereus*.

539 Number 2 of the map caption *G. gagei* should be *G. gaigei*.

540 Number 2 of the map caption *G. gagei* should be *G. gaigei*.

542 Number 2 of the map caption *G. gagei* should be *G. gaigei*.

546 Number 2 of the map caption *G. gagei* should be *G. gaigei*.

588 In the illustration caption, Anne Arundell should be Anne Arundel.

616 Line 1 of type locality - Notalbany should appear as Natalbany.

706 Variegated darter should appear as Variegate darter.

PLEASE NOTE: Pages 14, 52, 58, 66, 116, 142, 214, 274, 414, 426, 610, 712, 746, and 832 are blank to allow species accounts which were two pages to appear on opposite sides of the <u>same</u> piece of paper.

Institutions and addresses for the six primary authors of the Atlas (Lee, Gilbert, Hocutt, Jenkins, McAllister and Stauffer) can be found under Appendix B - Compilers - Page 849.

ERRATA sheets will be updated as time permits.

We would appreciate additional errors being brought to our attention. Forms for providing additional locality records will be provided upon request.

Natural Resources Inventory
Apalachicola-Chattahoochee-Flint River Basin

Prepared by

U.S. Fish and Wildlife Service Field Office
Panama City, Florida

James M. Barkuloo
Lorna Patrick
Lloyd Stith
Wm. Jay Troxel

July 1987

SPECIAL NOTE

This document was prepared as part of the ongoing U.S. Army Corps of Engineers, Mobile District's Apalachicola-Chattahoochee-Flint (ACF) Rivers Basin '308' Study. The Resource Inventory has been written from the viewpoint of the U.S. Fish and Wildlife Service with emphasis on natural resources of high Federal concern. The document should not be construed as a comprehensive account of all natural resources occurring in the ACF basin, nor a detailed discussion of all ecological relationships and functions of the system. The complex nature of the ACF system can not be adequately described in any one report, as evidenced by attention it has received by many Federal, State, and local governments, academic interests, conservation organizations and the public.

Table of Contents

Table of Contents (con't)

Tables and Figures

APALACHICOLA-CHATTAHOOCHEE-FLINT RIVER BASIN

The Apalachicola-Chattahoochee-Flint (ACF) River basin comprises 51,000 sq km (19,800 sq mi) in eastern Alabama, western Georgia, and northwestern Florida (Figure 1). Of the total basin 37,500 sq km (14,500 sq mi) are in Georgia, 7,299 sq km (2,800 sq mi) are in Alabama, and 6,500 sq km (2,500 sq mi) are in Florida. The ACF system because of its origin in the mountains and termination at the sea has a vast array of habitats and supports diverse fish and wildlife resources.

CHATTAHOOCHEE RIVER BASIN

OVERVIEW

The Chattahoochee River rises in the Blue Ridge Physiographic Province in northern Georgia, passes through the Red Hills of the Piedmont Province along the Georgia-Alabama state line, then flows through the rolling plains of the upper Coastal Plain to join the Flint River (Figure 2). The Chattahoochee River is 700 km (430 mi) long, drains 22,600 sq km (8,770 sq mi) and the maximum width of its basin is 89 km (55 mi). Its average annual flow is 12,210 cubic feet per second (Georgia DNR, 1976).

The Chattahoochee River begins in the Chattahoochee National Forest, White County, Georgia, in the Blue Ridge Mountains. This portion of the river and its tributaries are characterized by clear, cold water flowing over a rocky substrate. The north Georgia mountains are composed of mixed pine and hardwood forests. After leaving the Blue Ridge Province the river bottom is heavily canopied with the hardwoods typical along Piedmont rivers while the pine mix increases on the surrounding ridges. The lands adjacent to the river contain large areas of managed pine timberlands as well as agricultural areas. Special features of the upper basin are the river shoals and rapids on the river; the tributary creek watersheds (Blue Creek, Deep Creek, and Middle Mud Creek); the Flat Creek rock outcrops and shoals; numerous rare plant locales and natural areas, and the Leadpole and Skitt Appalachian foothill mountains (Georgia DNR, 1976).

The upper Chattahoochee River basin is roughly 32 km (20 mi) long and begins below the Nacoochee Valley with a width of 16 km (10 mi) along the foothills as the river leaves the Blue Ridge province. The basin then narrows to about .31 km (2 mi) in width with extensions along some of the ridge and tributary creek areas. The river drops 45 to 61 m (150 to 200 ft) as it moves through the basin with some of the drop displaced along river shoals, but most occurring in calm water areas of even gradient. The mountain foothills reach elevations over 600 m (2,000 ft) within the basin, but most of the Piedmont ridgelines average between 400 to 460 m (1,300 to 1,500 ft) in elevation, giving a height over the river of about .61 m (200 ft) (Georgia DNR, 1976).

The upper Chattahoochee River basin reflects the qualities of a riverine system which begins high in the Appalachians and drops into the Piedmont. The mountain section of the Chattahoochee River is included in the Blue Ridge province, so most of this area has the characteristics of the upper Piedmont (Georgia DNR, 1976). The river floodplain is much wider and the ridgelines are closely associated to faults and steep elevations of the northern Piedmont. The landscape features are not diverse but fairly uniform and indicative of the high ridge, hardwood dominated, and granite based upland Piedmont.

Figure 1: Apalachicola-Chattahoochee-Flint Drainage Basin.

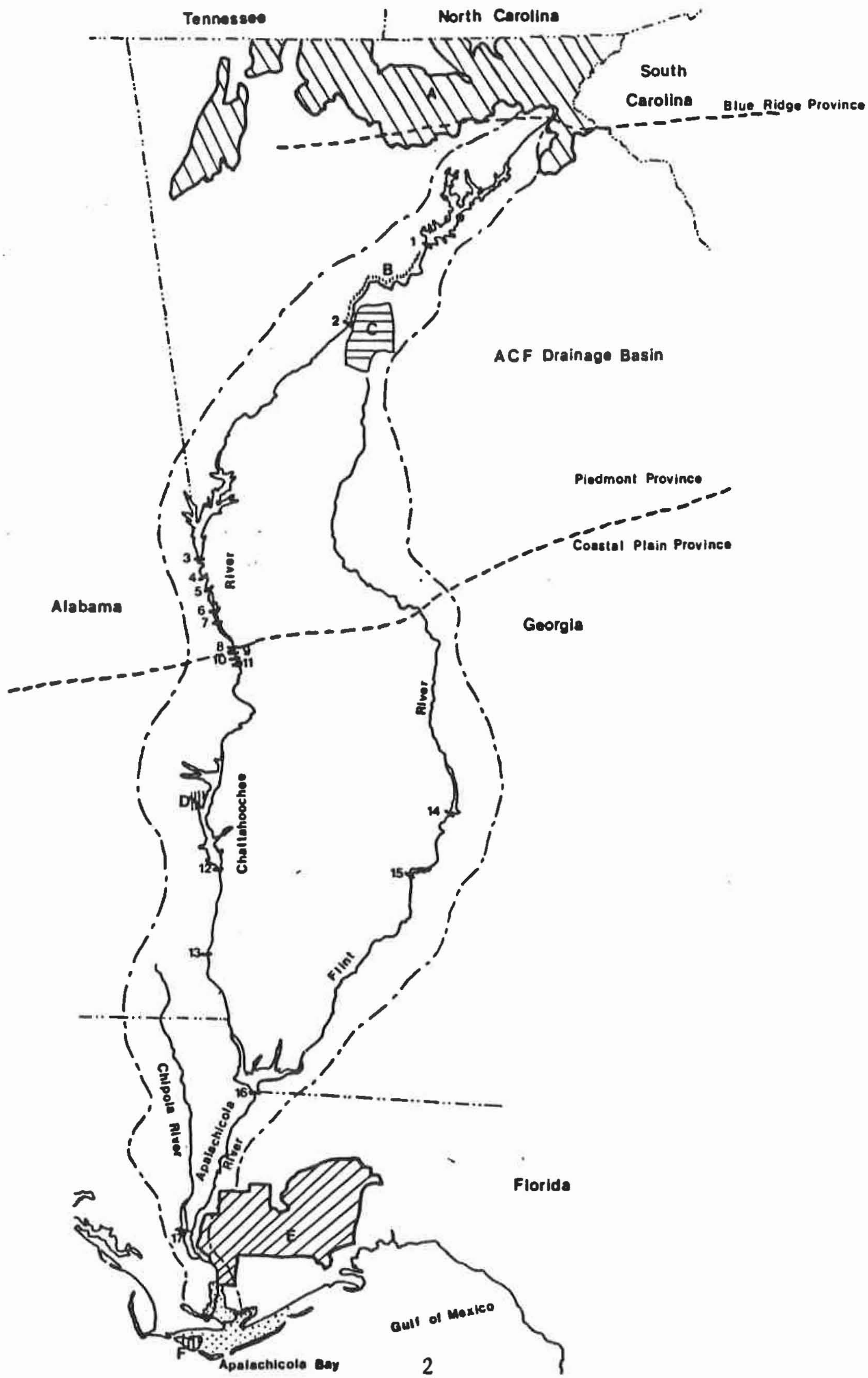
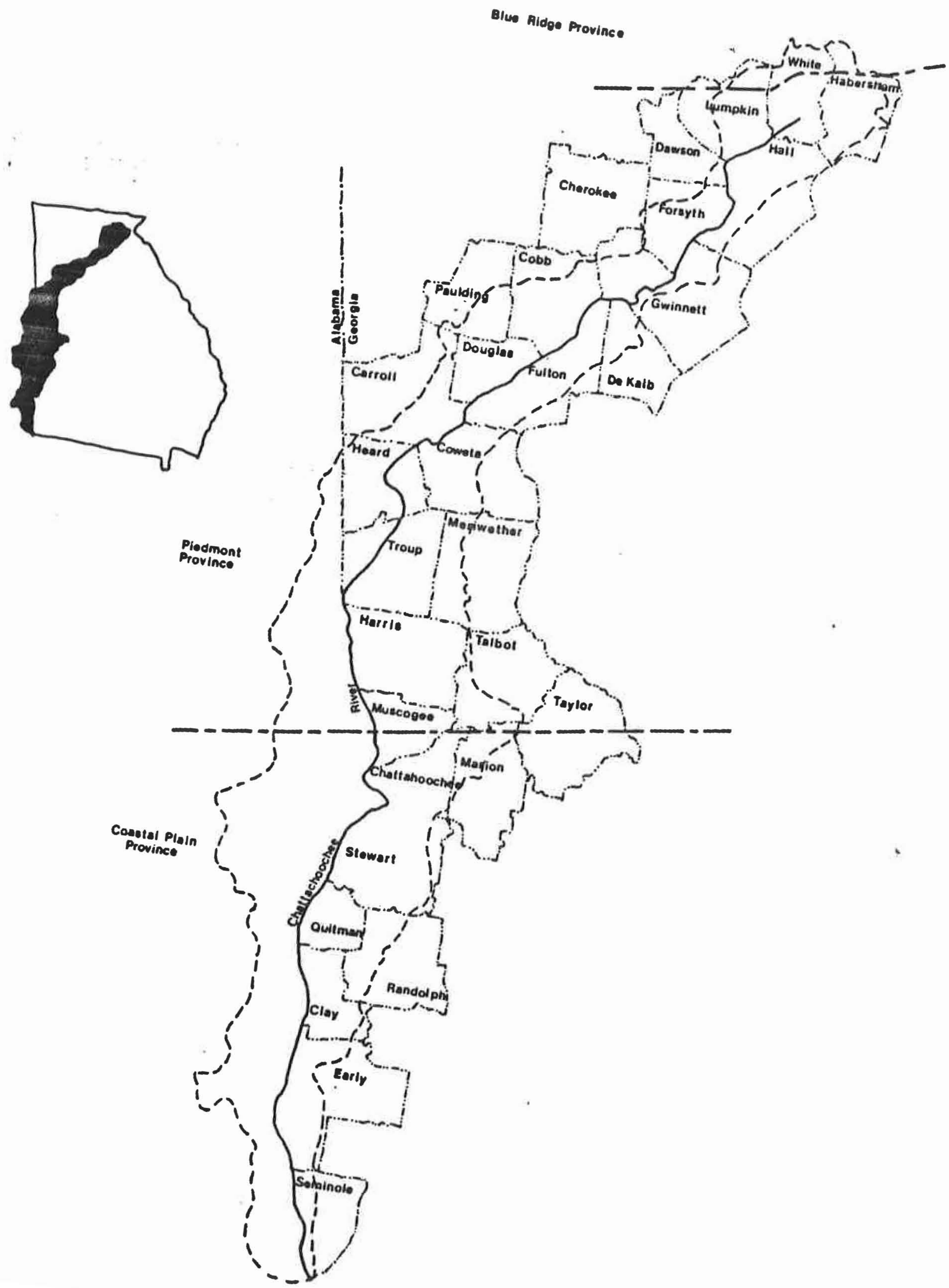


Figure 1 con't. Legend for Figure 1.

Chattahoochee National Forest	A
Apalachicola National Forest	E
Chattahoochee River National Recreation Area	B
Eufaula National Wildlife Refuge	D
St. Vincent National Wildlife Refuge	F
City of Atlanta	C
Buford Dam (COE)/Lake Sidney Lanier	1
Morgan Falls Dam (P)	2
West Point Lake and Dam (COE)	3
Langdale Dam (P)	4
Riverview Dam (P)	5
Bartletts Ferry Dam (P)	6
Goat Rock Dam (P)	7
Oliver Dam (P)	8
North Highlands Dam (P)	9
City Mills Dam (P)	10
Eagle-Phoenix Dam (P)	11
Walter F. George Lock, Dam and Lake (COE)	12
George W. Andrews Lock and Dam (COE)	13
Crisp County Dam (P)/Lake Blackshear	14
Albany Dam (P)/Lake Worth	15
Jim Woodruff Lock and Dam (COE)/Lake Seminole	16
Dead Lakes Dam (P)/Dead Lake	17

COE = U.S. Army Corps of Engineers
P = Private

Figure 2: Chattahoochee River Basin.



The upper Chattahoochee River basin is part of the Oak-Chestnut Forest Region. The American Chestnut (Castanea dentata), once forested the area, but due to blight and drought, the chestnut oak now dominates. Only in some very isolated areas can examples of the American chestnut be found. The slope which receives varying degrees of sunlight are forested by maple (Acer spicatum), beech (Fagus sp.), blackgum (Nyssa sylvatica), dogwood (Cornus spp.), ash (Fraxinus spp.), oak (Quercus spp.), willow (Salix spp.), sycamore (Platanus occidentalis), and pine (Pinus spp.). On some northern and eastern slopes, white pines (Pinus strobus) are abundant. The lower slopes have a dense canopy because of the hilly terrain and thus receives little or no direct sunlight. Such areas contain various types of ferns, azaleas, laurel, and the maple as common tree (Wharton, 1978).

The streamside shrub-herb zone of the Chattahoochee River headwaters is characterized by two habitat types. On the sandy bars and shores grow herbaceous annuals or young perennials: knotweeds (Polygonum spp.), jewelweed (Impatiens capensis), several species of panic grass (Panicum spp.), velvet grass (Holcus lanatus), and bent grass (Agrostis perennans). On the more stable rocky or gravel river margins grow alders (Alnus spp.), yellowroot (Xanthorrhiza simplicissima), elderberry (Sambucus spp.), bush honeysuckle (Lonicera sp.), Carolina rhododendron (Rhododendron minus), flame azalea (R. calendulaceum), witherrod viburnum (Viburnum cassinoides), St. John's wort (Hypericum fasciculatum), Virginia willow (Salix virginica), and perennials such as Carex, mountain dwarf dandelion (Krigia montana), Boykinia aconitifolia, Carolina baubane (Trautvetteria carolinensis), saxifrage (Saxifraga sp.), and the cinnamon fern (Osmunda cinnamomea) (Wharton, 1978). Because there is a wide variety of habitats for plants along the upper Chattahoochee River, many rare and endangered species are found in these habitats. Some rare Georgia plants include Brody's spiderwort (Tradescantia sp.), dwarf trillium (Trillium sp.), flat branch ground pine, glade fern (Athyrium pycnocarpon). golden seal (Hydrastis canadensis), painted trillium (Trillium undulatum), shortia (Shortia galacifolia), and the venus-hair fern (Adiantum capillus-veneris). Other rarities of this area include fairy wand, turk's cap lily (Lilium superbum), twisted hair fern, and yellow lady's slipper (Cypripedium calceolus) (Georgia DNR, 1977; Bowling, 1985).

The Chattahoochee River leaves Buford Dam below Lake Lanier, it occupies the lower Chattahoochee (Brevard) basin. The natural environments in the Chattahoochee River basin between Atlanta and Columbus are fairly typical Piedmont types, with second-growth hardwood and hardwood-pine forests and abandoned fields that are now covered with loblolly pine (Pinus taeda). This section of the basin is heavily canopied with a mixture of heights and densities and is related to the northern forest-type communities. There is an abundance of undergrowth, rock outcrops, and meadows throughout the basin which is typical for the Piedmont region. The basin has numerous land use zones consisting of urbanized and agricultural areas, water impoundments and reservoirs, and large areas of undeveloped land. Special features include the area where the Brevard Fault deepens to tightly enclose the basin; places such as the Palisades where the river drops across bedrock; the large number of rock outcrops; the wealth of smaller creeks that cascade into the fault zones from the north such as Whooping Creek, Snake Creek, Dog River, Sweetwater Creek, Soap Creek, Rottenwood Creek, Big Creek; the Chattahoochee River and Sweetwater Creek State Parks (Georgia DNR, 1976).

The basin in this area is approximately 4.8 km (3 mi) wide with widths averaging approximately 1.6 km (1 mi) through the Atlanta area and gradually expanding to around 19 km (12 mi) near the Alabama border. The river drops 61 to 91 m (200 to 300 ft) as it moves through the basin, with most of the drop being evenly displaced. There are a few areas of white water along the river which indicate a sharp drop but these are very limited. The higher ridges bordering the Brevard Fault/Chattahoochee River basin reach slightly over 300 m (1,000 ft) in elevation which give the basin a depth of from 46 to 76 m (150 to 250 ft). Shapes and patterns of the landscape are dependent on the deep ridge contours of the fault zone as combined with the densities of forest canopies and openness of agricultural and developed areas (Georgia DNR, 1976).

The predominate regional forest cover is oak-pine. Even in the Atlanta area, the basin contains significant features, such as bluff areas at the Palisades, where examples of the original oak-hickory-chestnut forest are visible (Georgia DNR, 1976). Mesic forests of the ravines and the lower north-facing slopes are compositionally similar to Appalachian hardwood forests to the north, and the species composition of the floodplain forests along the river is related to the bottomland hardwood forest of the Coastal Plain. In some areas, ravines leading to the river support beech forests. Older forests of oak-pine-hickory are present as the topography becomes more varied toward Buford Dam. Understory plants include dogwood, sourwood (Oxydendrum arboreum), young hardwoods, and vines. The extended northern species of the mesic forest include mountain camellia, galax (Galax aphylla), rhododendron, and ginger (Wharton, 1978).

The natural environments of the lower Piedmont Chattahoochee River basin between Atlanta and Columbus, Georgia were once dominated by a mixture of hardwoods. The lower basin is now extensively cultivated, with very little land remaining in its original natural condition. However, several of the more unusual environments occur along tributary streams that have cut deep corridors as they descend from the upland into the Chattahoochee River basin (Georgia DNR, 1976). According to Wharton (1978), the vegetation of the bluff forests, such as those of the north-facing valley walls along Upatoi Creek (just below Columbus) and other ravine-forming tributaries, show strong northern affinities, and hold botanical and zoological rarities.

The Chattahoochee River ravine gorges are found from Ft. Gaines, Georgia south, largely in Clay and Early Counties. The ravines are on bluffs which generally begin about 5 km (3 mi) east of the Chattahoochee River. According to Wharton (1978), these areas are geologically unusual in their flora and fauna. The near-vertical cliffs of laminated clay support venus-hair fern, and mountain laurel (Kalmia latifolia) are found along the ravines. Trees of these ravines include laurel oak (Quercus laurifolia), southern magnolia (Magnolia grandiflora), sugarberry (Celtis laevigata), sycamore, beech, box elder (Sambucus canadensis), black mulberry (Morus rubra), and alder.

The basin begins to widen here and is not confined as in the upper river. Much of the lands are heavily canopied with the southern pine and pine-hardwood communities of southern Georgia and Alabama. A large amount of the basin is being managed for timber. There are vast areas of hardwood lowland communities with pines abundant on most ridgelines. Numerous ravines and gullies have the dense hardwood covers and the ridges have lighter canopied pines. Loblolly-shortleaf pine with some southern red oak (Quercus falcata) predominate the uplands where dry soils prevail. The forests are a product of secondary succession.

The loblolly-shortleaf upland has replaced the original longleaf pine-wiregrass community and more recently, agricultural practices for corn, cotton, and tobacco production (Georgia DNR, 1976).

HISTORICAL/PRESENT UPLAND FORESTS

The American Indians began upland forest manipulation in the Chattahoochee River basin with their agriculture and use of fire. As a result, in the late 1700's settlers reaching the area observed fields, second-growth forests and occasional stands of pines. The settlers established cotton monoculture until demand for cotton declined in the 1930's. The land then reverted to a secondary forest with the pine forests being harvested for timber, pulpwood and used for naval store products (turpentine). These forest management practices hastened the return of the hardwood forests (Wharton, 1978).

The Chattahoochee River basin begins in the Blue Ridge/Foot Hills province and extends through the Piedmont to the Coastal Plain province (Wharton, 1978). The upper reaches of the Chattahoochee River basin is part of the Oak-Chestnut Forest Region. The American chestnut once forested the area, but due to blight and drought, the chestnut oak now dominates. The slopes which receive varying degrees of sunlight are forested by maple, beech, blackgum, dogwood, oak, willow, sycamore, and pine. On some northern and eastern slopes, white pines are abundant. The lower areas of the slope have a dense canopy because of the hilly terrain and receive little or no direct sunlight and contain various types of ferns, azaleas, laurel, and maple as common trees. The reduced sunlight limits the undergrowth along the lower slopes (Wharton, 1978).

The streamside shrub-herb zone of the Chattahoochee River headwaters is of two types. On the sandy bars and shores grow herbaceous annuals or young perennials: knotweeds, jewelweed and several species of panic grass, velvet grass, and bent grass. On the more stable rocky or gravel river margins grow alders, yellowroot, elderberry, bush honeysuckle, Carolina rhododendron, flame azalea, witherrod viburnum, St. John's wort, Virginia willow, and perennials such as sedges, mountain dwarf dandelion, Boykinia aconitifolia, Carolina buabane, saxifrage, and the cinnamon fern (Wharton, 1978). Because there are numerous habitats for plants along the Chattahoochee River, many rare and endangered species are found in the basin. Some of the rare plants include Brady's spiderwort, dwarf trillium, flat branch ground pine, glade fern, golden seal, painted trillium, shortia, and the venus-hair fern. Other rarities of this area include fairy wand, turk's cap lily, twisted hair fern, and the yellow lady's slipper (Georgia DNR, 1977; Bowling, 1985).

As a special note to the Blue Ridge Province of the Chattahoochee River Basin Wharton (1978) states that the southern Appalachians have been a mountain mass for hundreds of millions of years; thus, this region is considered to be a refuge for some of the oldest aggregations of plants, and perhaps animals, in North America. According to Little (1970), many plant genera in the southern Appalachians are relics from the Arcto-Tertiary flora, "the fossil plants of northern or Arctic regions in late Mesozoic and early Cenozoic eras".

Piedmont region forests of today consist of second growth deciduous hardwood and hardwood/pine mixtures. The probability of finding a virgin stand of hardwoods is remote (Wharton, 1978). Dominate hardwood species consist of scarlet oak (Quercus coccinea), black oak (Quercus velutina), southern red

oak, (Quercus falcata) and chestnut oak (Quercus prinus), co-dominants include shagbark hickory (Carya ovata), long-leaf pine (Pinus palustris), pignut hickory (Carya glabra), sugar maple (Acer saccharum), and sweetgum (Liquidambar styraciflua). Subcanopy dominants consist of dogwood, eastern red bud (Cercis canadensis), red mulberry (Morus rubra), sourwood, red maple, winged elm (Ulmus alata), sparkleberry (Vaccinium arboreum), and Georgia hackberry (Celtis tenuifolia). The shrub layer includes such species as blueberry (Vaccinium sp.) and paw paw (Asimima triloba). Although relatively scarce, herbs to be found are muscadine grape (Vitis rotundifolia), greenbriers (Smilax sp.), mint (Calamintha spp.), wintergreen (Gaultheria spp.), goldenrod (Solidaga spp.), and asters (Aster spp.) (Wharton, 1978).

While hardwood forests predominate in the Piedmont upland, needleleaf evergreen forests predominate on the Coastal Plain. These forests have also been altered by the activities of man. Today's forests are pine and/or pine-hardwood mixtures. The forests were originally longleaf pine, but are now mixed with slash pine (Pinus elliottii), shortleaf pine (Pinus echinata), and loblolly pine. The pine forests have little to no woody understory, although in some locales the southern red oak is sometimes found. Shrubs and vines are the primary understory species and consist of gallberry (Ilex sp.) and runner oak (Quercus pumila). The ground cover varies with location but usually includes wiregrasses (Aristida spp.), flea-bane (Erigeron sp. and Pluchea rosea), deer tongue (Trilisa spp.), gold aster (Chrysopsis sp.), wild indigo (Baptisia lanceolata), gopher apple (Geobalanus oblongifolius) and cone flower (Rudbeckia spp.). In the lower Coastal Plain the "pine flatwoods" are longleaf, slash or pond pine (Pinus serotina) with a heavy shrub ground cover of saw palmetto (Serenoa repens), gallberry, blueberry and dwarf oak (Quercus minima). The pine/hardwood forests consists of shortleaf pine, mockernut hickory (Carya tomentosa), red oak, black oak, post oak (Quercus stellata) and dogwood (Wharton, 1978).

The Chattahoochee River basin south of the Fall Line at Columbus, Georgia moves into the Coastal Plain. Forested with pines and pine-hardwood mixtures, the lower basin is now extensively cultivated, with very little land remaining in its original natural condition. However, several disjunct habitats occur along tributary streams that have cut deep ravines as they descend from the upland to the Chattahoochee River. According to Wharton (1978), the vegetation of the bluff forests, such as those of the north-facing valley walls along Upatoi Creek (just below Columbus) and other ravine-forming tributaries, show strong northern affinities, and hold botanical and zoological rarities.

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The Chattahoochee River basin upland forests (hardwood and/or pine) currently provide good habitat for wildlife species, especially in the upper and middle basin areas. Hardwood forests are important as wildlife habitat, particularly when mast-producing species such as oak and hickory are numerous, and the understory provides browse for deer. The mast-producers not only provide winter food for deer, but also are a prime food source for squirrels. Important deer browse

species include honeysuckle, greenbriar, ivy (Rhus radicans), grape (Vitis spp.), dogwood, blueberry, and sparkleberry. The hardwood forest also provides habitat for songbirds, owls, and hawks. Some hunting by carnivores such as fox, weasel, and mink takes place in the hardwood forest, though these forms prefer the bottomlands.

Pine dominated forests provide habitat for a variety of wildlife, especially birds. Owls utilize the pines for cover; cavity-nesting birds inhabit mature pines as do pine warblers and other songbirds. Pines also provide food, shelter and habitat for the fox squirrel and other small mammals. The deciduous oak and hickory species provide mast for wildlife such as deer and squirrels. The understory is an important provider of browse for wildlife. The actual wildlife productivity values and diversity that the evergreen forest provides are dependent on whether it is natural or planted. Evergreen forests in natural succession usually provide a greater diversity of food sources and cover than intensively managed pines plantations.

Upland forests are one of the main habitats found along the Blue Ridge/Piedmont region of the upper and middle Chattahoochee River basin. Except where agricultural and residential areas occur, the forests line the river. In the basin's Coastal Plain, forested areas are greatly reduced by agriculture (crops, grazing, silviculture) which mostly border the river. Intensively managed pine plantations in this portion of the basin probably make up a majority of the so-called upland pine forests.

URBAN AREAS

The Chattahoochee River basin is relatively rural except for the Atlanta and Columbus/Phenix City areas. The Atlanta metropolitan area with a population of 2,260,100 is growing rapidly and spreading in all directions (Rand McNally, 1987). In the upper reaches of the basin, population concentrations occur at Gainesville having a population of 15,280 (Gainesville City Hall, 1986). Below Atlanta the Columbus/Phenix City area has approximately 172,200 people (Columbus City Hall, 1986). Eufuala, Alabama has a population of 12,000 and Dothan although not directly on the river banks but in the drainage has a population of 55,000 (Eufaula City Hall, 1986; Dothan City Hall, 1986; Rand McNally, 1987).

Generally, urban areas located on the river impact the system by direct development. In addition, the use of the river for domestic and industrial water supply can alter normal flow, if a minimum river flow is not maintained. Discharge of inadequately treated domestic or industrial wastewaters may degrade the integrity of the river system. In the Chattahoochee River headwaters a dramatic increase in the level of tourism in the City of Helen in recent years has resulted in excess of the permitted water quantity discharge. Accompanying this, there have been higher levels of fecal coliform bacteria downstream of the City. Plans for upgrading the treatment system and other facilities are in process (Georgia EPD, 1984a).

The heaviest demands placed on the Chattahoochee River occur in the Atlanta area, where the river supplies water to over one-third of the State of Georgia residents. Municipal water supply, hydropower production, irrigation, wastewater assimilation and recreation all compete for a finite water supply. Below Atlanta,

the water quality of the river is impaired by the large volume of treated wastewater it must assimilate. However, the river usually meets its classification standard of "fishing and recreation" (Georgia EPD, 1984a).

Because the river water is unsuitable for a municipal supply south of Atlanta, local governments are dependent upon either tributary streams, limited ground water supplies or for purchase from other local governments. The river itself has been modified to accomodate industry water users (Georgia EPD, 1984a).

Below the City of Columbus water supplies are abundant, urban development is sparse, such that the river water quality and quantity has not been impaired. However, irrigation uses in southwestern Georgia are increasing at such a rate that substantial decrease of the Chattahoochee River's base flow will occur if activities are not stabilized (Radtke et al., 1980; Georgia EPD, 1984a).

AGRICULTURE

Agricultural lands (crops, pasture, siliviculture) are sparse throughout the Chattahoochee River drainage basin except in the extreme southwestern portion of Georgia (Georgia DNR, 1976). In the headwaters of the Chattahoochee River agriculture is rare due to terrain conditions. Where it occurs small intrusions into the landscape are created by agricultural pastures and farmlands. There are however large areas of managed timberlands of pine (Georgia DNR, 1976).

From Buford Dam to Atlanta agricultural lands are again rare. The alluvial soils found along the river floodplains are good agricultural soils, but the floodplain is subject to periodic flooding. Southward from Atlanta agriculture is largely floodplain farming consisting of pastures or crops which limits other development along the river (Georgia DNR, 1976).

Below Columbus, Georgia, agriculture becomes the dominant land use within the basin. At the Fall Line and in the upper Coastal Plain large areas are in silviculture primarily pine plantations (Georgia DNR, 1976).

In the lower Coastal Plain of southwest Georgia cultivated crops compose the majority of the land use activity. Multiple "cropping" is now a common practice because of the long growing season. Crops generally grown include corn, grain sorghum, peanuts, soybeans, tobacco, pecans, peaches, and vegetables. The increase and expansion of such agricultural practices has resulted in ground water pumping for irrigation to have increased 200% between 1977 and 1981. A Georgia Geological Survey and U.S. Geological Survey mathematical model to simulate future irrigation use shows aquifer discharge to streams will be reduced by 30% if withdrawals for irrigation continue to increase. This would substantially affect the base flow of the Chattahoochee River in southwest Georgia (Georgia DNR, 1976; Radtke et al., 1980).

In summary, agriculture has not severely impacted the Chattahoochee River basin except for in southwest Georgia; and if agriculture continues to increase in that area the affect on the river system may be substantial.

WATER QUALITY

The Chattahoochee River is the most heavily used water resource in Georgia. The overall water quality of the river is very good with a significant number of headwater tributaries classified as primary or secondary trout streams (Georgia EPD, 1984a).

A dramatic increase in the level of tourism in the City of Helen in recent years has resulted in discharges from the treatment plant in excess of the National Pollutant Discharge Elimination System (NPDES) permit limitation of water quantity discharge. Accompanying this hydraulic overloading has been high levels of fecal coliform bacteria downstream of Helen. These problems are being alleviated somewhat by a switch to septic tank/drainfield system and plans for upgrading the treatment plant in the future (Georgia EPD, 1984a).

The heaviest demands placed on the Chattahoochee River predictably occur in the Atlanta area, where the river supplies over one-third of the State's residents. Municipal water supply, hydropower production, irrigation, wastewater assimilation and recreation all compete for a finite water supply. Below Atlanta, the water quality of the river is impaired by the large volume of treated wastewater it must assimilate. However, the river usually meets its classification standard of "fishing and recreation", although the problem becomes more acute during low flow periods. Several actions are occurring or in the planning stages to correct problems in the Atlanta area. In 1972, Congress authorized the ten-year Metropolitan Atlanta Water Resources Study (MAWRS) conducted by the Savannah District, U.S. Corps of Engineers (COE). In cooperation with State and local governments, regional water supply and wastewater management plans have been developed. In addition, plans for construction of a small reregulation reservoir below Buford Dam are being conducted. The Atlanta Three Rivers Project completed in 1985 was a massive and complex engineering effort to upgrade treatment facilities and redirect discharge to improve the water quality in the Flint and Oculgee River Basins. The project removed the discharge of (Chattahoochee River) treated wastewater into the Flint and Ocmulgee River Basins to new discharge points along the Chattahoochee River. Other extensive efforts by the State and local governments (including the Atlanta Regional Commission (ARC)) continuously work on the water supply issue (Georgia EPD, 1984a; U.S. COE, 1987).

South of Atlanta adequate management of the Chattahoochee River is extremely critical since the river water is unsuitable for municipal withdrawal until West Point Reservoir. There is also a lack of substantial dependable ground water supplies. Local governments are dependent upon either tributary streams, limited ground water supplies, or purchase from other local governments. In 1979, Congress authorized the South Atlanta Study for counties adjacent and south of the Atlanta area to study the area's water supply needs and to develop a regional water supply framework of the limited surface and groundwater resources in the area (Georgia EPD, 1984a; Lehman, 1987).

Below the Fall Line near the City of Columbus the Coastal Plain of the Chattahoochee River basin possesses abundant surface and ground water resources. Significant water resources development from West Point Lake to Lake Seminole provides power generation and reliable water supplies. Surface water use in the lower basin is concentrated in the La Grange and Columbus areas. Municipal and industrial facilities away from the main stem of the Chattahoochee River are dependent on ground water supplies. Agricultural irrigation is the major ground water user in the Coastal Plain (Georgia EPD, 1984a). In fact, increase and expansion of agricultural practices in southwestern Georgia has resulted in ground water pumping for irrigation to have increased 200% between 1977 and 1981. A Georgia Geological Survey and U.S. Geological Survey mathematical model to stimulate future irrigation use shows aquifer discharge to streams will be reduced by 30% if withdrawals for irrigation continue to increase. This would substantially affect base flow of the Chattahoochee River in southwest Georgia (Radtke et al., 1980).

STREAMS AND FLOODPLAINS

Flowing through three physiographic provinces, the Chattahoochee River basin spans a broad variety of aquatic environments (Wharton, 1978). The headwaters are in White County, Georgia in the Chattahoochee National Forest in the Blue Ridge Mountains. The upper river and its tributaries are characterized by clear, cold water flowing over a boulder and bedrock substrate with numerous falls, pools, shoals, and rapids. The water quality of these uppermost streams is excellent, and they are very popular for trout fishing (Georgia DNR, 1976).

As the Chattahoochee River flows toward Lake Lanier it enters the Piedmont Physiographic Province. The river changes in this area, slowing as the gradient decreases, and the substrate turns to sand, gravel, and silt. Natural trout water disappears as the water temperature increases and the silt load becomes heavier. Between its headwaters and Lake Lanier, approximately nine major creeks and rivers flow into the Chattahoochee River. They include Smith Creek, Dukes Creek, Sautee Creek, Blue Creek, Suque River, and Hogen Creek. The Chattahoochee River within this region drains areas of crystalline rocks. Thus, the water is low in mineral content and is siliceous in type (Georgia DNR, 1976).

As the Chattahoochee River leaves Buford Dam below Lake Lanier, the water is quite cold, and an excellent trout fishery has been established in the dam's tailwaters. Below Buford Dam the river enters the Brevard Fault zone where it drops across bedrock with a large number of rock outcrops occurring. The river drops 61 to 91 m (200 to 300 feet), with most of the drop being evenly displaced. There are a few areas of white water although they are limited. The small tributaries cascade into the main system filled with small waterfalls, riffles and pools like the mountain streams of north Georgia. Some of these are Whooping Creek, Snake Creek, Dog River, Sweetwater Creek, Soap Creek, Rottenwood Creek, and Big Creek (Georgia DNR, 1976).

The ground water in this section occurs under water table conditions. Springs, which are common are usually of the seepage type. The water is siliceous and soft with total mineral content ranging between 30 and 70 ppm. Closer to Atlanta the turbidity increases and since 1965 this is believed to be due to development along the river. As the Chattahoochee River flows through Atlanta, water quality problems occur from municipal and industrial wastewater treatment facility discharges (Georgia DNR, 1976).

As the Chattahoochee River flows into West Point Lake to the Florida State line a series of public and private reservoir projects have altered the river system, although the river flows through areas of special physiographic and topographic features.

The first such special feature is the Pine/Oak Mountain ridgeline, where the river drops 15 m (50 feet) quickly. As the Chattahoochee River enters the Sand Hills/Talbotton area it falls another 15 m (50 feet) but is evenly displaced because of a wide river bottom. This area takes the Chattahoochee River from the Piedmont into the Coastal Plain Province. Most of the tributary creeks carry the muddy brown sediment typical of the lower Piedmont, although some of the creeks that arise and remain mostly in the sandhills can be characteristic of the upper Coastal Plain with clear to dark water (Georgia DNR, 1976).

Below the City of Columbus the elevation of the Chattahoochee River is fairly constant and the river has been impounded to form Walter F. George Lake. The Red Hills (special feature area) reach an elevation of nearly 183 m (600 ft) over the water level of the river in a short distance, causing deep ravines and cascades on the tributary creeks as they flow to the river. Because of the highly eroding Red Hills clay the creeks carry large amounts of sediment (Georgia DNR, 1976). Below Walter F. George Lake the Chattahoochee River consists mainly of two more reservoirs to the Florida State line. George W. Andrews Lakes is essentially riverine while Lake Seminole is primarily a reservoir extending to the George W. Andrews Lock and Dam.

The river bottomland in the upper Chattahoochee River basin is heavily canopied with typical Piedmont hardwoods such as sycamore, willow, ash, and maple with sparse undergrowth. South of Atlanta lowland hardwoods such as poplar (*Liriodendron tulipifera*), sweetgum, sycamore, river birch (*Betula nigra*), hornbeam (*Oostrya virginiana*), and water oak (*Quercus nigra*) border the river with the understory generally sparse, and even clear in places, consisting of low plants, vines and young hardwoods. In some areas moist ravines leading to the river support beech forests (Georgia DNR, 1976).

South of Atlanta to north of Columbus, Georgia, the floodplain is largely farmed or consists of undeveloped land. The topography is flat and the scattered pastures and agricultural lands abut the river (Georgia DNR, 1976). As the river passes through the Pine/Oak Mountain Ridgelines the adjacent lands are relatively undeveloped due to the terrain. While the uplands in the Sand Hill/Talbotton area are dominated by pines the hardwoods dominate the ravines adjacent to the river.

Below Columbus into the Coastal Plain Province extensive hardwood lowlands are found along the river, where they have not been altered or eliminated by construction of large reservoirs.

LAKES AND IMPOUNDMENTS

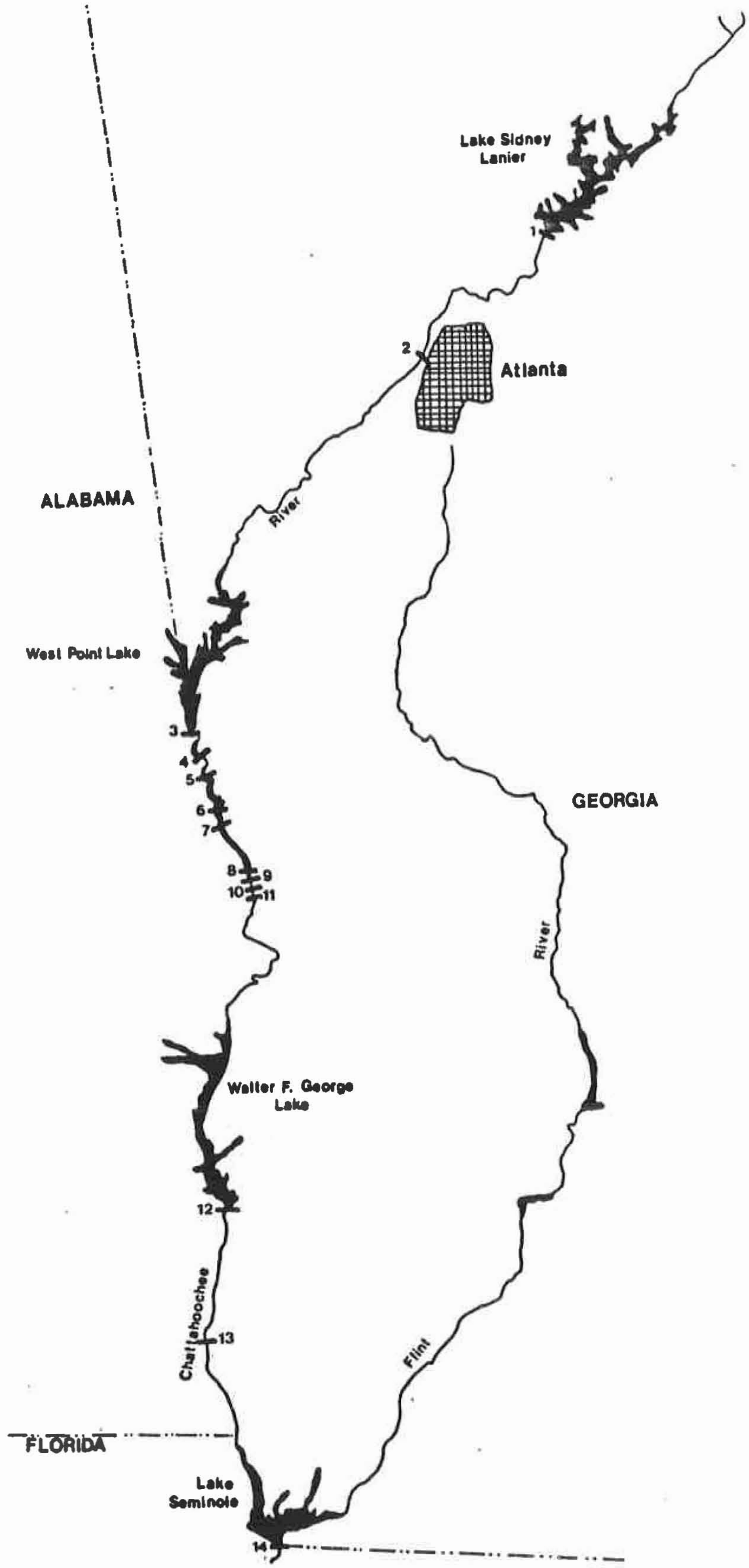
U.S. Army Corps of Engineers

Lake Sidney Lanier

Lake Sidney Lanier is the most upstream impoundment on the Chattahoochee River, located about 57 km (35 miles) northeast of Atlanta, Georgia (Figure 3). Lake Sidney Lanier was created by the construction of Buford Dam in 1960. The Buford Dam project is a multi-purpose project with purposes of flood control, navigation, water supply, power, and recreation. The lake at maximum flood control pool elevation 330 m (1,085 ft) has an area of 19,000 ha (47,182 acres) and has a drainage area of 270,000 ha (1,040 sq miles) (U.S. COE, 1984a).

Fish population and harvest surveys conducted by Georgia Game and Fish Division in 1979 showed that all game fish species were in excellent condition. Largemouth bass (*Micropterus salmoides*) and spotted bass (*M. punctulatus*)) were the number one species caught in Lake Lanier with spotted bass composing 75% of the black bass harvest. Sunfish (mainly bluegill (*Lepomis macrochirus*)) and crappie (*Pomoxis* spp.) were the next species caught in abundance. Striped bass (*Morone saxatilis*) and catfish (*Ictalurus* spp.) were also species caught

Figure 3: Lakes and Impoundments of the Chattahoochee River Basin (see Figure 1 for legend).



in significant numbers. Since the surveys were conducted during the day only, population and harvest numbers of crappie, rainbow trout (Salmo gairdneri), and white bass (M. chrysops) were lower than expected (Georgia DNR, 1980e).

Striped bass have been stocked in the lake since 1973, and in 1979 the best striped bass populations were located in the Flat Creek, and Balus Creek, Six Mile Creek and Bald Ridge Creek areas of the lake. Also trout have been stocked in the lake since 1980 (Georgia DNR, 1980e).

West Point Lake

West Point Lake (formerly West Point Dam and Reservoir) was created by the construction of West Point Dam in 1975. Purposes of the project include flood control, hydroelectric power, recreation, fish and wildlife development, area development, and stream flow regulation for downstream navigation. At full power-pool the lake has an area of 10,500 ha (25,864 acres). West Point Lake covers parts of Troup and Heard Counties in Georgia and Chambers and Randolph Counties in Alabama (Figure 3) (U.S. COE, 1984a).

The Corps of Engineers has funded and/or conducted several fisheries and limnological studies on the West Point Lake to study the fact that in large impoundments fish production, measured in terms of yield of sport fishes, usually declines after reaching a peak during the first three to eight years of impoundment. Results from studies on the lake indicate it is moderately productive (mesotrophic) and, when compared to other southeastern reservoirs, it produces a high standing crop of fish. There was no verifiable change in the standing stock estimates from 1975 to 1980 and the expected decline of standing stock had not occurred (U.S. COE, 1984b). Important game fishes in the reservoir from 1975 to 1977 were largemouth bass, bluegill, black crappie (Pomoxis nigromaculatus) and channel catfish (Ictalurus punctatus) (Timmons et al., 1977). Alabama Game and Fish Division rated West Point Lake in 1986 as the number two spot in Alabama for largemouth bass fishing (Mobile Press, 1986). Striped bass hybrids have been stocked in the lake from 1975 to 1986, at a total of 2,462,079 fish (Georgia DNR, 1975).

Lake Walter F. George

Lake Walter F. George was created by the construction of the Walter F. George Lock and Dam in 1963 and is located between Fort Gaines and Columbus, Georgia (Figure 3). The 137 km (80 mile) long lake has a normal pool elevation 58 m (190 ft) and has an area of 18,280 ha (45,181 acres), and a total drainage area of 1,932,955 ha (4,776,502 acres). The project was constructed for navigation and hydropower and has 9 X 100 foot navigation channel extending its entire length. The lake is basically a run-of-the-river facility that floods onto the old river floodplain in the lower portions of the reservoir. Lake George is well known in the southeastern United States for its trophy size largemouth bass. When compared with other southwest Georgia reservoirs, it has an average fish population, but relatively low fishing pressure and harvest (Keefer, 1980).

Lake Walter F. George has shown the change in fishery populations expected in impoundments. After the first five years (1968) of impoundment Georgia Game and Fish Division population surveys indicated the reservoir has matured. Reduction of most standing fish crop was observed except for a dramatic increase of the carp population. The survey also showed largemouth bass, bluegill, channel catfish, carp (Cyprinus carpio), and gizzard shad (Dorosoma cepedianum) were the dominate species found in the lake (Keefer, 1980).

The 1976-1978 creel survey showed that crappie was the most important species harvested with largemouth bass, bluegill and catfish also making up a significant portion of the catch (Keefer, 1980).

The States of Alabama and Georgia have been stocking the lake with hybrids (white bass x striped bass) since 1975, a total of 4,453,261 fish (Georgia DNR, 1987). An outstanding year class of hybrids was established in 1977, however harvest and collection success rates have decreased since then. Reasons for this are not known. It could be due to the lack of knowledge of local fisherman on how, when and where to catch them. Reports from some fisherman and bait shop owners, indicate some anglers were making good catches, particularly in the tailrace area and in the upper reaches of the reservoir. Also, since the fish population survey ended in 1978, and hybrid stockings began in 1975, the maximum fishery potential may not have fully developed (Keefer, 1980).

When the fish population of Lake Walter F. George was compared to those of three other southwest Georgia reservoirs (Keefer, 1978; Weaver, 1979; and unpublished data), total standing crop was found to be somewhat less than in either Lake Seminole or Bartlett's Ferry Reservoir (Chattahoochee River) but slightly more than that observed in Lake Blackshear (Flint River) (Keefer, 1980).

Comparison of creel survey data of the lake with six nearby reservoirs shows Lake Walter F. George to have a low total harvest, harvest rate, and annual catch per hectare. The low harvest may be due in part to low fishing pressure since anglers from most of the States' major population centers usually have closer reservoirs to fish. Other factors may include: lack of shore development (many fishermen prefer to fish close to the shoreline), morphometry of the lake tends to magnify the influence of weather, loss of fishery habitat due to deterioration of the brush type fish shelters, and relatively poor motel and marine facilities available on the lake (Keefer, 1980).

In summary, Lake Walter F. George appears to be a typical Georgia mainstream reservoir with an average fish population but with relatively low fishing pressure and harvest (Keefer, 1980).

The Eufaula National Wildlife Refuge, within and adjacent to the Walter F. George reservoir is located 9.7 km (six miles) north of Eufaula, Alabama and encompasses 4,516 ha (11,160 acres) of which approximately 2,000 ha (5,000 acres) is water. The refuge was established to provide a protected area for waterfowl in the winter and as mitigation for the Walter F. George Lock and Dam Project. The Refuge experienced approximately 136,000 visits in 1985 for recreational fishing activities. Species caught included largemouth bass, crappie, catfish, and bream (Temple, 1986). The State of Alabama also rated Lake Eufaula as number six of the top ten places to largemouth bass fish in 1986 (Mobile Press, 1986).

Lake George W. Andrews

Lake George W. Andrews located in Alabama and Georgia, was completed in 1963 by the construction of the George W. Andrews Lock and Dam (formerly Columbia Lock and Dam). The 45.6 km (28.3 mile) long lake created by this dam at normal pool elevation 31 m (102 feet) has an area of 623 ha (1,540 acres). The project was single-purposed for navigation and has a 9 X 100 navigation channel extending its entire length. The reservoir is immediately upstream of Lake Seminole and

extends up to Walter F. George Lock and Dam, and is strictly a run-of-the-river facility (Figure 3) (U.S. COE, 1984a).

The reservoir above the dam is primarily riverine habitat as compared to reservoir habitat, although the fish species composition is similar to what is found in Lake Seminole. In 1981, 1982 and 1986, 74,163 striped bass hybrids were stocked into the lake (Georgia DNR, 1987).

Lake Seminole

Lake Seminole, formed by Jim Woodruff Lock and Dam (JWLD), is located partially within each of three states: Georgia, Florida, and Alabama and was completed in 1957 (Figure 3). The reservoir has a total drainage basin area of 4,471,714 ha (11,050,000 acres), of which approximately 51% is tributary to the Chattahoochee River and 49% tributary to the Flint River. The reservoir consists of two major arms extending up the Flint and Chattahoochee valleys, and two minor arms, Fish Pond Drain and Spring Creek, both of which are tributary to the Flint River arm. The reservoir has a surface area of 15,227 ha (37,628 acres). The pool extends up the Chattahoochee River 75.2 km (46.6 mi) to the George W. Andrews Lock and Dam and up the Flint River 76 km (47 mi) (U.S. COE, 1981).

The primary project purposes are to aid navigation in the Chattahoochee River upstream to the George W. Andrews Lock and Dam, in the Flint River to Bainbridge, Georgia, and downstream in the Apalachicola River; and, to generate electric power. Other benefits include the regulation of streamflows, public recreation, and fish and wildlife conservation. The reservoir is a run-of-the-river facility and there is no flood control storage available in the reservoir (U.S. COE, 1981).

Physically, the sediments of the reservoir range from sands to loam. Aquatic weeds have been a problem in the lake since it began to fill. The first control measures were taken in 1955 when water hyacinth (*Eichhornia crassipes*) was sprayed with 2,4-D. In 1973 an aquatic plant survey of Lake Seminole identified over 400 species, of which 70 were classified as noxious or potentially noxious plants. A survey done by the U.S. Corps of Engineers in 1979 showed the dominant aquatic vegetation to be Eurasian milfoil (*Myriophyllum spicatum*), giant cutgrass (*Zizaniopxis miliacea*), hydrilla (*Hydrilla verticillata*), water hyacinths and a blue-green algae, *Lyngbya* sp. Various weed control measures have been attempted in the past by the Corps. Mechanical cutters, various types of chemical applications, and biological controls have been used. With the exception of the control of water hyacinth with 2,4-D and the control of alligator weed (*Alternanthera philoxeroides*) with the Argentine flea beetle (*Agasicles hygrophila*), weed control methods have been unsuccessful in reducing the aquatic weed problem except on a short term basis (U.S. COE, 1981). The 1987-88 aquatic weed control program will concentrate on water hyacinths, giant cutgrass and hydrilla. The hyacinths and cutgrass are treated by airboat using 2,4-DMA and RODEO respectively. Hydrilla will be treated with SONAR SRP spread by helicopter. Some problems are expected with American lotus, salvinia, and pond weed, but treatment has not been determined. Concern has been expressed for Lake Seminole and Apalachicola River water quality due to the large acreages and therefore large amounts of herbicide to be used with application by aircraft (FL DNR, 1987; FDE, 1987). The combination of large shallow water areas and a warm climate seem to guarantee that Lake Seminole will have severe aquatic weed problems for the foreseeable future.

Of the reservoirs in the ACF basin, Lake Seminole contains one of the best fisheries in Georgia. The Georgia Game and Fish Division began to survey the fish populations in Lake Seminole in 1959. A total of 37 rotenone fish population studies have been conducted thru 1981 concerned with overall fisheries population and structure, 26 of which were conducted during the period 1959 through 1971. Largemouth bass, bluegill, spotted sucker (Minytrema melanops), channel catfish, and gizzard shad were the dominant species.

The most recent published fish population and sport fishery survey occurred from July 1977 to July 1981 and was conducted by the Georgia Game and Fish Division. Sampling showed largemouth bass, redear sunfish (Lepomis microlophus), bluegill, carp, channel catfish, spotted gar (Lepisosteus oculatus), and gizzard and threadfin shad (Dorosoma petenense) were the most dominant species. Other significant game fish species found included warmouth (Lepomis gulosus), redbreast (L. auritis), spotted sunfish (L. punctatus), and channel catfish (Keefer, 1981b).

A local sport fishery for striped bass existed in the Flint River and Spring Creek areas prior to the impoundment of Lake Seminole. This fishery was essentially eliminated in the late 1950's when Jim Woodruff Dam was closed. From 1965 through 1972, fishery workers with the Georgia Game and Fish Division attempted to raise striped bass in a nursery pond in the Silver Lake area of Lake Seminole with apparently little success. In addition to nursery efforts, striped bass fry and fingerlings were stocked directly into the lake periodically from 1965 through 1974 and again in 1980. The failure to establish a striped bass fishery before 1975 prompted a switch to stocking hybrids (white bass x striped bass). A total of 3,713,790 hybrid fingerlings and 1,192,500 fry have been stocked in Lake Seminole from 1975 through 1986. Striped bass fingerlings were also stocked in Lake Seminole in 1966, 1968, 1974, 1980 and 1985 amounting to 462,867. Of that total, 374,400 were Gulf Coast strain fish which biologists from the U.S. Fish and Wildlife Service felt would be better adapted to life in the river system (Keefer, 1981b; 1986; Georgia DNR, 1987).

Studies conducted by Georgia Game and Fish Division concerning striped bass were conducted from 1975-1985. These studies indicate that although reproduction is taking place, spawning has not been successful except in 1974 (a strong 1977 year class was found). Further, the study shows that the population of adult fish is relatively limited, providing a small potential brood population (Keefer, 1986b; 1986).

Although the adult population is limited, striped bass in Lake Seminole and the Flint River provides a unique trophy fishery that has a potential to produce a new all-tackle world record striped bass. Three line test category world records recognized by the International Game Fish Association are held by fish caught in the Flint River at Albany (Keefer, 1986).

Sampling for striped bass hybrids in the lake was conducted from the fall of 1976 through the fall of 1980 by the Georgia Game and Fish Division. Catch rates were relatively low in 1976, but increased dramatically in 1977 after the 1975 stockings, and remained high through 1980. As a result of the stockings a significant hybrid fishery currently exists at George W. Andrews Lock and Dam above Lake Seminole. Further, biologists with the U.S. Fish and Wildlife Service began to recover Morone hybrids in the Apalachicola River below Lake Seminole in 1976, the year after they were first stocked in the lake, and prior to the State of Florida stocking them directly into the river in 1978. A substantial hybrid fishery now exists below Lake Seminole (Keefer, 1981b).

Sport fishing harvest data taken from January 1978 through December 1979 shows anglers on Lake Seminole expended an annual average of approximately 587,000 hours on fishing taking an annual average of approximately 770,000 fish. In descending order of numbers the following fish were caught bluegill, catfish, crappie, redear sunfish and largemouth bass (Keefer, 1981b).

Comparison of Lake Seminole standing crop with the average crops of major Georgia reservoirs and the average and maximum standing crops for 173 reservoirs in the mid-south reveals that the standing crops of largemouth bass, black crappie, redear, carp, white catfish, gizzard shad, threadfin shad and several species of minor importance were higher in Lake Seminole than either the Georgia statewide average or the mid-south average for these species (Keefer, 1981b).

The fish population and angler harvest observed in Lake Seminole compare favorably to other reservoirs in Georgia and in the south. Overall total catch rates when compared to six other Georgia reservoirs were higher in Lake Seminole in all cases except for Goat Rock Reservoir (Chattahoochee River), and that difference was slight. Total harvest per hectare of bluegill was higher in Lake Seminole than in any of the other six reservoirs examined. Harvest of largemouth bass was higher than every reservoir except Lake Sinclair (Oconee River) (Keefer, 1981b).

Lake Seminole also supports a small, local, commercial/recreational, gill netting fishery for spotted sucker and redhorse sucker (Moxostoma spp.). Although it is a local, more social event, (some fish are sold) the use of gill nets requires the issuance of a commercial fishing license. This is allowed in only a certain portion of Lake Seminole, and it is the only lake in Georgia where it is allowed (Keefer, 1981b).

Private Impoundments

The Chattahoochee River has nine (9) privately owned dams. Eight of the sites are located between river miles 261.5 and 309.2 between the Columbus and La Grange, Georgia; the ninth facility is at Atlanta, Georgia (Figure 3). (All River Mile (RM) data with reference to mouth of Apalachicola River, FL) All of the structures are privately owned power generating facilities, and are essentially run-of-the river structures with minimal storage, and do not have a significant impact on the regulation of the river (Georgia EPD, 1984a).

RM	266.8	Eagle-Phoenix Dam (Fieldcrest Mills)
RM	267.6	City Mills Dam (City Mills)
RM	268.9	North Highlands Dam (Georgia Power Co.)
RM	270.0	Oliver Dam (Georgia Power Co.)
RM	278.6	Goat Rock Dam (Georgia Power Co.)
RM	284.4	Bartletts Ferry Dam (Georgia Power Co.)
RM	297.0	Riverview Dam (Georgia Power Co.)
RM	298.5	Langdale Dam (Georgia Power Co.)
RM	3190	Morgan Falls Dam (Georgia Power Co.)

Georgia Game and Fish Division surveyed in 1978-1979 three of the Georgia Power Company reservoirs, Bartlett's Ferry reservoir, Goat Rock reservoir, and Lake Oliver. Bartlett's Ferry reservoir and Lake Oliver supported primarily a boat fishery, while a majority of anglers at Goat Rock Reservoir favored bank fishing. Sport fishing for catfish composed a significant portion of the total harvest in all three reservoirs, with largemouth bass, bluegill and crappie also contributing a significant portion of the catch. White bass and hybrids have been stocked in all three reservoirs and a small number of adult sauger (Stizostedion canadense) were stocked in Bartlett's Ferry and Lake Oliver in 1961. The three reservoirs were determined to provide angling on a par with most other area reservoirs for most species (Keefer, 1981a).

Bull Sluice Lake (Morgan Falls) is heavily sedimented and shallow due to development activities in the upper Chattahoochee River basin. Some recreational fishery does occur for yellow perch (Perca flavescens), largemouth bass, and sunfish. Brown trout (Salmo trutta), brook trout (Salvelinus fontinalis), and rainbow trout were stocked in the upper portion of the lake in 1977 and only rainbow trout in 1978 (Hess, 1980). However, the habitat in the lake is no longer suitable for trout and does not support a significant fishery.

RIVERINE FISHERY RESOURCES

Eighty-six different species of fish have been identified in the Chattahoochee River drainage basin (Table 1) (Martin, 1973). Physiographic isolation of the Chattahoochee River makes it the major dividing line between the Atlantic and Gulf coast drainages (Gilbert, 1969).

The river fishery habitat of the Chattahoochee River consists primarily of: (1) shoal areas where the river widens and has relatively shallow water, steep gradients, and a rock substrate; (2) sandy runs where the river is moderately wide with shallow water, a moderate gradient, and a shifting sand substrate; and (3) deep pools where the river is fairly narrow and has deep water, almost no gradient, and a silt substrate (Hess, 1980).

The upper river and its tributaries are characterized by clear, cold water. The water quality of these uppermost streams is excellent, and are very popular for brook, rainbow and brown trout fishing. Waters Creek in the Chattahoochee National Forest has trophy size trout due to the State of Georgia feeding the fish. The trout attain a size of 2.7-3.2 kg (6-7 lbs). Other coldwater species fished for in the Forest include smallmouth and the redeye bass (Seehorn, 1986).

As the Chattahoochee River flows toward Lake Lanier it changes, slowing as the gradient decreases. Natural trout waters dissappear as the water temperature increases and the silt load becomes heavier. Warm water species occurring in the area include largemouth bass, smallmouth bass (Micropterus dolomieui), walleye (Strizostedion vitreum), white bass, channel catfish, and bluegill (Georgia DNR, 1976).

As the Chattahoochee River leaves Buford Dam below Lake Lanier, the water is quite cold, and an excellent trout fishery has been established in the dam's tailwaters. According the the Georgia Game and Fish Division, the 77 km (48 miles) of the Chattahoochee River below Buford Dam is considered a coldwater stream and has been managed as a trout fishery since 1960, after Lake Lanier was impounded. This area, known as the Buford Dam Tailwaters, is one of the southernmost trout fisheries in the nation (Hess, 1980) and has been developed into the most productive put-and-take stream in Georgia.

Harvestable-size rainbow, brook and brown trout are stocked in the upper river by Georgia Game and Fish Division and juvenile brown trout are stocked below Morgan Falls Dam with the assistance of Trout Unlimited. Long-term survival of stocked brown trout has produced trophy-sized fish, particularly downstream from Morgan Falls Dam (Nestler et al., 1985).

Although trout are the most sought after fish by anglers, warmwater fish also occur within the upper Chattahoochee River. Creel surveys showed bluegill was the dominant fish taken with significant numbers of yellow perch, brown bullhead (Ictalurus nebulosus), largemouth bass and carp also being taken. The Chattahoochee River below Morgan Falls Dam and upstream of the confluence with Peachtree Creek is one of the prime trout fishing areas probably because of ease of access, nearness to population centers of Atlanta, and availability of excellent trout habitat (Nestler et al., 1985; Hess, 1980).

Several major types of angling activities occur in the upper river, determined by ease of access and channel morphology. Near boat ramps, fishing from canoes and small boats with low power outboard engines is popular. In areas where access is more difficult, bank fishing, wade-fishing, and tube-fishing is more popular. Angling activity is most concentrated in the shoal areas and in areas where fish are stocked (Nestler et al., 1985).

The fish fauna of the central Chattahoochee River drainage is sparse compared to adjacent river systems. This possibly is due to the relative homogeneity of habitat, general infertility of the area, and to physiographic isolation. The Fall Line was found to be less important as a barrier to fish movements in the river than in adjacent systems (Gilbert, 1969).

The remainder of the Chattahoochee River below Atlanta strictly supports a warmwater fishery for largemouth bass, striped bass, white bass, bass hybrids, redeye bass (Micropterus coosae), shoal bass (M. sp. c.f. M. coosae), spotted bass, crappie, yellow perch, pickerel (Esox spp.), channel catfish, and several varieties of sunfish.

The Chattahoochee River has been substantially altered by creation of impoundments, especially in the lower river so that the majority of recreational fishing occurs on the impoundments on the basin.

The Chattahoochee River also provides suitable habitat for commercial species of fish, which include the American eel (Anguilla rostrata), snail bullhead (Ictalurus brunneus), white catfish, yellow bullhead (I. natalis), brown bullhead, channel catfish, and spotted bullhead (I. serracanthus) (U.S. COE, 1984b).

Table 1: Fish Species Found in the ACF Basin
From: Martin, 1973; Molley, 1977; Yerger, 1977.
X^s = "put and take fishery" (stocked) and natural reproduction

Common Name	Scientific Name	Apalachicola	Chattahoochee	Flint
Southern brook lamprey	Ichthyomyzon gagei	X	X	X
Atlantic sturgeon	Acipenser oxyrhynchus	X		
Gulf Coast sturgeon	Acipenser oxyrhynchus desotoi	X		
Spotted gar	Lepisosteus oculatus	X	X	X
Longnose gar	Lepisosteus osseus	X	X	X
Bowfin	Amia calva	X	X	X
American eel	Anguilla rostrata	X	X	X
Alabama shad	Alosa alabamae	X	X	X
Skipjack herring	Alosa chrysochloris	X	X	X
Rainbow trout	Salmo gairdneri		X^s	
Brown trout	Salmo trutta		X^s	
Brook trout	Salvelinus fontinalis		X^s	
Gizzard shad	Dorosoma cepedianum	X	X	X
Threadfin shad	Dorosoma petenense	X	X	X
Redfin pickerel	Esox americanus	X	X	X
Chain pickerel	Esox niger	X	X	X
Stoneroller	Campostoma anomalum	X	X	X
Carp	Cyprinus carpio	X	X	X
Silverjaw minnow	Ericymba buccata	X	X	X
Bigeye chub	Hybopsis amblops		X	X
Redeye chub	Hybopsis harperi	X	X	X
Unnamed chub	Hybopsis sp. c.f. H. winchelli	X	X	X
Bluehead chub	Nocomis leptocephalus		X	X
Golden shiner	Notemigonus crysoleucas		X	X
Bluestripe shiner	Notropsis callitaenia	X	X	X
Rough shiner	Notropis baileyi		X	
Blacktip shiner	Notropis atrapiculus		X	
Spottail shiner	Notropis hudsonius		X	
Flagfin shiner	Notropis signipinnis	X		
Coosa shiner	Notropis xaenocephalus		X	
Ironcolor shiner	Notropis chalybaeus	X		X
Dusky shiner	Notropis cummingsae	X	X	X
Pugnose minnow	Notropis emiliae		X	X
Broadstripe shiner	Notropis euryzonus		X	X
Sailfin shiner	Notropis hypselopterus	X	X	X
High scale shiner	Notropis hypsilepis	X	X	X
Longnose shiner	Notropis longirostris	X	X	X
Yellowfin shiner	Notropis lutipinnis			X
Taillight shiner	Notropis maculatus	X	X	X
Coastal shiner	Notropsis petersoni	X	X	X

Table 1: con't. Fish Species Found in the ACF Basin
From: Martin, 1973; Molley, 1977; Yerger, 1977.
X^s = "put and take fishery" (stocked) and natural reproduction

Common Name	Scientific Name	Apalachicola	Chattahoochee	Flint
Weed shiner	*Notropsis texanus*	X	X	X
Blacktail shiner	*Notropsis venustus*	X	X	X
Bluenose shiner	*Notropsis welaka*	X	X	X
Bandfin shiner	*Notropsis zonistius*	X	X	X
Unnamed shiner	*Notropsis sp.* c.f. *N. bellus*		X	X
Fathead minnow	*Pimephales promelas*			X
Creek chub	*Semotilus atromaculatus*	X	X	X
Quillback	*Carpiodes cyprinus*	X	X	X
Creek chubsucker	*Erimyzon oblongus*		X	X
Lake chubsucker	*Erimyzon sucetta*	X	X	X
Spotted sucker	*Minytrema melanops*	X	X	X
Blacktail redhorse	*Moxostoma poecilurum*		X	
Greyfin redhorse	*Moxostoma sp.* c.f. *M. poecilurum*	X	X	X
Greater jumprock	*Moxostoma lachneri*		X	X
Striped jumprock	*Moxostoma rupiscartes*			X
Snail bullhead	*Ictalurus brunneus*	X	X	X
White catfish	*Ictalurus catus*	X	X	X
Yellow bullhead	*Ictalurus natalis*	X	X	X
Brown bullhead	*Ictalurus nebulosus*	X	X	X
Channel catfish	*Ictalurus punctatus*	X	X	X
Spotted bullhead	*Ictalurus serracanthus*	X	X	X
Black madtom	*Noturus funebris*	X		
Tadpole madtom	*Noturus gyrinus*	X	X	X
Speckled madtom	*Noturus leptacanthus*	X	X	X
Flathead catfish	*Pylodictis olivaris*		X	X
Pirate perch	*Aphredoderus sayanus*	X	X	X
Banded topminnow	*Fundulus cingulatus*	X		
Lined topminnow	*Fundulus lineolatus*			X
Blackspotted topminnow	*Fundulus olivaceus*		X	
Southern studfish	*Fundulus stellifer*		X	
Golden topminnow	*Fundulus chrysotus*	X		X
Starhead minnow	*Fundulus notti*	X	X	X
Pygmy killifish	*Leptolucania ommata*	X		
Bluefin killifish	*Lucania goodei*	X		
Mosquitofish	*Gambusia affinis*	X	X	X
Least killifish	*Heterandria formosa*	X	X	X
Brook silverside	*Labidesthes sicculus*	X	X	X
Striped bass	*Morone saxatilis*	X	X	X
White bass	*Morone chrysops*	X	X	X
Hybrid	*Morone saxatilis* x *M. chrysops*	X	X	X

Table 1: con't. Fish Species Found in the ACF Basin
From: Martin, 1973; Molley, 1977; Yerger, 1977.
X^S = "put and take fishery" (stocked) and natural reproduction

Common Name	Scientific Name	Apalachicola	Chattahoochee	Flint
Reciprocal hybrid	Morone chrysops x M. saxatilis	X	X	X
Rock bass	Ambloplites ariommus		X	X
Flier	Centrarchus macropterus	X	X	X
Everglades pygmy sunfish	Elassoma evergladei	X		X
Banded pygmy sunfish	Elassoma zonatum	X	X	X
Okefenokee pygmy sunfish	Elassom okefenokee	X		
Bluespotted sunfish	Enneacanthus gloriosus	X		X
Orange spotted sunfish	Lepomis humilis	X		X
Longear sunfish	Lepomis negalotis	X	X	
Redbreasted sunfish	Lepomis auritus	X	X	X
Green sunfish	Lepomis cyanellus	X	X	X
Warmouth	Lepomis gulosus	X	X	X
Bluegill	Lepomis macrochirus	X	X	X
Dollar sunfish	Lepomis marginatus	X	X	X
Redear sunfish	Lepomis microlophus	X	X	X
Spotted sunfish	Lepomis punctatus	X	X	X
Redeye bass	Micropterus coosae		X	X
Smallmouth bass	Micropterus dolomieu		X	
Spotted bass	Micropterus punctulatus	X	X	
Shoal bass	Micropterus sp. c.f. M. coosae	X	X	X
Largemouth bass	Micropterus salmoides	X	X	X
White crappie	Pomoxis annularis	X	X	X
Black crappie	Pomoxis nigromaculatus	X	X	X
Brown darter	Etheostoma edwini	X	X	X
Swamp darter	Etheostoma fusiforme	X	X	X
Goldstripe darter	Etheostoma parvipinne	X	X	X
Gulf darter	Etheostoma swaini	X	X	X
Yellow perch	Perca flavescens	X	X	X
Blackbanded darter	Pecina nigrofasciata	X	X	X
Sauger	Stizostedion canadense	X	X	
Walleye	Stizostedion vitreum		X	
Striped mullet	Mugil cephalus	X		X
Mountain mullet	Agonostomus monticola	X		
Hogchocker	Trinectes maculatus	X	X	X
Atlantic needlefish	Strongylura marina	X	X	X
Alabama hogsucker	Hypentelium etowanum		X	
Mottled sculpin	Cottus bairdi		X	
Banded scuplin	Cottus carolinae		X	
Southern flounder	Paralichthys lethostigma	X		

WILDLIFE RESOURCES

The Chattahoochee River floodplain environment represents a diverse biotic corridor containing a variety of habitat types, from bare cliffs with pioneer biotic communities through xeric hilltops to wet swamp forests. The various habitats provide for the diversity in the faunal assemblage. While being diverse, the fauna is not extraordinary or unique (Troxel and Haynes, 1985).

The upper Chattahoochee River basin in the mountainous areas support wildlife species such as black bear (Ursus americanus), wild turkey (Meleagris gallopavo), white tailed deer (Odocoileus virginianus), ruffed grouse (Bonasa umbellus, raccoon (Procyon lotor), beaver (Castor canadensis), squirrel (Sciurus carolinensis, S. niger, Glaucomys volans), mourning dove (Zenaida macroura) and quail (Colinus virginianus) (Georgia DNR, 1976). Public hunting in the mountains occurs primarily in the Chattahoochee National Forest for deer, turkey, and grouse.

The Chattahoochee River floodplain in the Piedmont region support a vertebrate fauna similar to that of other Piedmont floodplains. Some deciduous forest bluff species, such as the slimy and red-backed salamanders (Plethodon glutinosus glutinosus, Plethodon cinereus cinereus), are sometimes found in higher parts. The Chattahoochee River fauna includes amphibians such as the newt (Notophthalmus spp.), the spade foot toad (Scaphiopus holbrooki holbrooki), and Fowler's toad (Bufo woodhousei fowleri). The green anole (Anolis carolinensis carolinensis), and the 5-lined skink (Eumeces fasciatus) inhabit the Chattahoochee River floodplain in the Piedmont region, whereas the other skink species are confined to the bluff forests. The spadefoot toad and the 6-lined racerunner (Cnemidophorus sexlineatus) are probably present because of the lessened flood events and the sandy nature of the floodplain which is good for burrowing. These sandy conditions also support small mammal fauna such as the semifossorial pine vole (Pitymys pinetorum) and the fossorial mole (Scalopus aquaticus) (Wharton, 1978).

According to Wharton (1978), the most common birds in the Georgia Piedmont river floodplain bottomlands in general are the prothonotary, parula and magnolia warblers (Protonotaria citrea, Parula americana, and Dendroica magnolia respectively), alder and Acadian flycatchers (Empidonax alnorum, Empidonaz virenscens), Chuck-will's-widow (Caprimulgus carolinensis), and the redbreasted and pileated woodpeckers (Centurus carolinus, Dryocopus pileatus). Flocks of robins (Turdus migratorius), waxwings (Bombycilla spp.) and blackbirds (Euphagus spp., Agelauis spp.) pass through during migration. The red-shouldered hawk (Buteo lineatus) and barred owl (Strix varia) are mostly confined to the river swamps (Wharton, 1978).

Wildlife species include white tailed deer, bobcat (Lynx rufus), raccoon, opossum (Didelphis marsupialis), squirrel, eastern cottontails (Sylvilagus floridanus, S. aquaticus), muskrats (Ondatra zibethicus), beaver, river otter (Lutra canadensis), and mink (Mustela vison) as well as other small mammals. The rare freshwater mollusk (Anodontoides elliotti) occurs here in the Chattahoochee River system.

In the Piedmont region of the Chattahoochee River basin 1984 deer population estimates range from 15 to 30 deer per square mile (less than one deer per acre).

Cobb, Dekalb, Douglas, Fulton, Gwinnett and Rockdale Counties, metropolitan in nature support 15-20 deer per square mile, while Carroll, Coweta, Heard, and Troup Counties support 20-30 deer per square mile. Current annual harvest estimates show Douglas County with 360 deer, Fulton and Rockdale Counties with 250 deer, and Gwinnett County with 130 deer harvested. Carroll, Coweta, Heard and Troup Counties harvest estimates show 11 deer per square mile (Georgia DNR 1985b, 1985c).

Turkey and small game population and harvest information was unavailable for the area. On the Piedmont, 112 licenses were sold in 1984 to individuals for commercial trapping. Species taken include raccoon, bobcat, red fox (Vulpes vulpes), gray fox (Urocyon cinereoargenteus), otter, mink, muskrat, beaver and opossum (Georgia DNR, 1985d).

The Chattahoochee River basin in the Coastal Plain has been heavily altered by agricultural development either for crops or siliviculture. However, the lower basin supports substantial wildlife populations of deer and turkey with small game including bobwhite quail, mourning dove, gray squirrel, fox squirrrel, cottontail rabbit, raccoon, and opossum. Mink, muskrat, beaver, skunk (Mephitis mephitis), weasel (Mustela frenata), otter, gray fox, red fox, and bobcat are the small furbearers in the area (U.S. COE, 1984b).

In the Coastal Plain of the Chattahoochee River basin, 1984 deer population estimates range from 460 deer in Seminole County to 13,180 in Stewart County. In descending order the deer populations occurring in the other counties are: Chattahoochee (7,920), Early (6,120), Harris and Muscogee (5,220), Quitman (3,880) and Clay (2,610). Deer harvest in the counties ranged from 468 deer in Quitman County to 3,295 deer in Stewart County (Georgia DNR, 1985a).

Chattahoochee County has the highest turkey population with 1,800 turkey and Seminole County has the lowest population with 45 turkey. Harris County has the second highest population with 1,000-1,500 turkey. The remaining counties range from 500 to 600 turkey. In those counties with 1984 turkey seasons Chattahoochee County had the highest harvest of 125 turkeys with the others having a general harvest range of 15-100 turkeys (Georgia DNR, 1985a).

Throughout the Flint and Chattahoochee River basins on the Coastal Plain a total of 282 State of Georgia licenses were sold to individuals for commercial trapping in 1984. The major species trapped were raccoon, bobcat, red and gray fox, otter, mink, coyote (Canis latrans), and muskrat (Georgia DNR, 1985a).

STATE/FEDERAL WILDLIFE MANAGEMENT AREAS

There is only one State of Georgia Wildlife Management Area in the Chattahoochee River basin and no State Alabama Wildlife Management Areas.

Chattahoochee Wildlife Management Area

The Chattahoochee Wildlife Management Area (WMA) consists of 9,700 ha (24,000 acres) within the Chattahoochee National Forest managed by the State of Georgia under cooperative lease agreement with the U.S. Forest Service.

The majority (54%) of the WMA consists of hardwood forests vegetated by red oak, white oak and hickory. Understory species consist of mountain laurel, rhododendron, huckleberry, dogwood and sourwood. Yellow pine and white pine forests

compose approximately 19% and 14% respectively of the WMA with mixed pine-hardwood, mixed hardwood-pine and cove hardwood forests making up the remainder of the Forest. Trout streams found in the WMA include the Chattahoochee River, Low Gap Creek, Jasus Creek and Dukes Creek (Georgia DNR, 1985g).

The main management goal of the WMA is to provide public hunting approximately 8,650 hunter-days annually. Other goals established for the area include protection of rare and endangered flora and fauna and maintaining diversity of small game and nongame species.

The 1985 prehunt deer population estimate was approximately 15 deer per square mile (0.02 deer per acre) and projected future management plans estimate a population of 25 deer per square mile (0.04 deer per acre) and harvest of 180 deer annually by the year 1990. Current turkey population estimates show approximately 10 turkey per square mile (0.02 per acre). Projected future management plans estimate a goal of 12 turkeys per square mile (0.02 per acre) with harvest of 24 turkeys by the year 1990 (Georgia DNR, 1985g). Current population estimates of the black bear show approximately one bear per 405 ha (1,000 acres). The future goal density is the same as currently occurring on the WMA. Projected future harvest estimates are five bear annually by the year 1990. Other species specifically managed for include gray squirrel, raccoon, cottontail rabbit, bobwhite quail, ruffed grouse, mourning dove, wood duck, red and grey fox, eastern cougar, pink and yellow Lady's slipper, songbirds and raptors (Georgia DNR, 1985g).

Although silviculture is practiced, the timber is managed for optimal conditions for wildlife species. Managed timber types include cove and upland hardwoods, Virginia pine, yellow pine, and white pine (Georgia DNR, 1985g).

The largest public use of the WMA is hunting, with deer and turkey being the preferred game. A 1984 survey indicated that 51% of the hunters were from the local area; 17% were nonlocal, rural; 27% were nonlocal, urban; and 4% were non-residents of Georgia. Deer hunting accounted for approximately 3,057 user-days in 1984; and turkey hunting accounted for 750 user-days for the same year.

Small game hunting is currently an underutilized opportunity due to low small game populations and rugged mountain terrain. Small game, mostly squirrel, raccoon, and grouse accounted for 930 user-days in 1984.

Additional camping and fishing activities are not encouraged at the present time due to overuse along existing trout streams. Currently 7,600 user-days are accomplished for fishing activities on the WMA.

Non-consumptive activities such as hiking, nature study, or tourism constitute other activities available on the WMA (Georgia DNR, 1985g).

The Raven Cliffs Scenic Area 640 ha (1,589 acres) has been set aside in the WMA for preservation. Approximately another 1,800 ha (4,500 acres) have been proposed to be included into this preservation area (Georgia DNR, 1985g).

Chattahoochee National Forest

The Chattahoochee National Forest is located in the Chattahoochee River headwaters. The National Forest encompasses 283,200 ha (700,000 acres) lying across the southernmost reaches of the Appalachian mountains. The Forest contains the

southern portion of one of the most extensive and productive hardwood forests of the world. The Forest also contains an example of the ridge and valley physiological province found in Virginia (Seehorn, 1986).

Although all fish and wildlife species are managed by the Forest, particular species are managed as "management indicator species". These species represent how the forest management practices are working. Major game indicator species include the white tailed deer, turkey and ruffed grouse and non-game species such as the pileated woodpecker (Seehorn, 1986).

As in all National Forests the Forest Service has a cooperative agreement with the State for management of the Forest. The Forest Services' primary responsibility is habitat management. All public hunting and fishing on the Chattahoochee National Forest is accomplished according to State of Georgia regulations although the Forest does impose stricter regulations on particular areas within the Forest (Seehorn, 1986).

Public hunting occurs throughout the Forest, major large game species taken include deer, turkey and ruffed grouse. Black bear hunting has just been allowed in the Forest as of last year. Small game species taken include squirrel, rabbit, raccoon, and some quail. There are seven special wildlife management areas within the forest (they make-up one-third to one-half of the Forest acreage) that have additional restrictions on hunting than as required by the State (Seehorn, 1986).

Eufaula National Wildlife Refuge

Eufaula National Wildlife Refuge (NWR) was established in 1964 and contains 4,500 ha (11,160 acres) within and adjacent to the Walter F. George Reservoir and is managed by the U.S. Fish and Wildlife Service. The refuge, located approximately 9.7 km (6 miles) north of Eufaula, Alabama is bisected by the Chattahoochee River Valley and consists of 3,200 ha (8,000 acres) in Alabama and 1,200 ha (3,200 acres) in Georgia. The refuge is strategically located on the southeastern edge of the Mississippi Flyway and the southwestern edge of the Atlantic Flyway. The habitats in the refuge are of good diversity supporting many wildlife populations (U.S. FWS, no date).

The refuge was created primarily to provide feeding and resting habitat for waterfowl migrating through the Tennessee Valley to the Gulf Coast. Impoundments and the waters of the Walter F. George Reservoir make up nearly half of the refuge acreage. The remaining acreage is upland areas consisting of agricultural land and forest. Farming is the primary waterfowl management practice providing wintering areas for large concentrations of ducks and geese. Agricultural lands are planted in corn, grain sorghum, and Japanese millet and are then flooded in late fall making the crops available to migratory waterfowl. Many other wildlife species are attracted by the diversity of habitat on the refuge. The refuge bird list identifies 204 species that have been observed on the refuge (U.S. FWS, no date).

The refuge supports good wading bird populations including great egrets (Casmerodius albus), great blue herons (Ardea herodias) and little blue herons (Egretta caerulea). A rookery of 5,000-8,000 birds consisting of cattle egret, great and little blue herons and anhingas (Anhinga anhinga)

occur on the refuge. For the first time in twenty years an osprey (Pandion haliaetus) has nested on the refuge (Temple, 1986).

Endangered or threatened species found on the refuge include an alligator (Alligator mississippiensis) population of 250, occasional use by wood storks and year round usage by bald eagles (Haliaetus leucocephalus). Bald eagles have attempted twice to nest adjacent to the refuge (Temple, 1986).

Public hunting (at certain times) is allowed on the refuge with approximately 2100 visits per year for that reason. Major game species taken include dove, quail, rabbit, deer, and waterfowl. The majority of the waterfowl taken are mallards (Anas platyrhynchos) (70%) with ring-necks (Aythya collaris), wood duck (Aix sponsa), green winged teal (Anas crecca) and coot (Fulica americana) composing the remainder of the species (Temple, 1986).

SPECIAL, UNIQUE OR SENSITIVE ECOLOGICAL AREAS

Chattahoochee National Forest

The headwaters of the Chattahoochee River are surrounded by the Chattahoochee National Forest. The Forest comprises 283,200 ha (700,000 acres) in north Georgia, lying across the southernmost reaches of the Appalachian Mountains and includes the southern portion of one of the most extensive and productive hardwood forests in the world. The Forest also contains a small portion of the Ridge and Valley physiological province as found in Virginia. The Forest is also the southernmost limits for wild trout and ruffed grouse populations (Seehorn, 1986).

The Forest is known for its hunting of ruffed grouse, deer and turkey; fishing for rainbow, brook and brown trout, smallmouth bass and redeye bass; white water rafting, picnicking, hiking, photography, and the study and enjoyment of nature (Seehorn, 1986).

Chattahoochee River National Recreation Area

The Chattahoochee River National Recreation Area (CRNRA) occurs along a 77.4 km (48 mi) length of the river between Buford Dam and the confluence with Peachtree Creek, and is managed by the U.S. National Park Service. The CRNRA was established to protect the river's most significant natural environments. These environments represent an overlap of Appalachian and Coastal Plain species within the Piedmont region. The CRNRA is also known for its trout fishing and white water recreational sports (Nestler et al., 1985).

Ravine Habitats

As the Chattahoochee River flows south from the Fall Line several unusual environments occur along tributary streams that have cut deep ravines as they descend from the upland to the river. According to Wharton (1978), the vegetation of the bluff forests, such as those of the north-facing valley walls along Upatoi Creek (just below Columbus) and other ravine-forming tributaries, show strong northern affinities, and hold botanical and zoological rarities.

The ravine communities are also found in riverine gorges from Ft. Gaines, Georgia, south, largely in Clay and Early Counties. The ravines are on bluffs which generally begin about 4.8 km (3 miles) east of the Chattahoochee River. According to Wharton, (1978), these areas are geologically unusual in their flora and fauna. The near-vertical cliffs of laminated clay support venus-hair fern, and mountain laurel is found along the ravines. Trees of these ravines include laurel oak, southern magnolia, sugarberry, sycamore, beech, box elder, black mulberry, and alder.

Red Hills/Sandhills

The Fall Line/Red Hills are remnants of ancient shoreline dunes (Georgia DNR, 1976). The plants found in these regions are adapted to grow in extremely arid and intensified sunlight areas. The area is forested and composed of pine and pine-hardwood communities. The dominant tree is the turkey oak. Other common species include the bluejack oak (Quercus marilandica), Margaret oak, and the longleaf pine. Some of the understory shrubs are chickasaw plum, sparkleberry, dangle-berry, and one-flowered thorn (Georgia DNR, 1976). The common fern is the brackens, while spike moss and various lichens are all found in the area.

The Red hills also have seldom found or disjunct plant and animal communities. The animal community may best be described as a burrowing fauna. These species are the gopher tortoise (Gopherus polyphemos), pocket gopher (Geomys pinetis), beach mouse (Peromyscus spp.), gopher frog (Rana areolata aesopus), crown snake (Tantilla coronata), and rattlesnake (Crotalus spp., Agkistrodon spp.) (Georgia DNR, 1976).

Eufaula National Wildlife Refuge

Eufaula National Wildlife Refuge, established in 1964, contains 4,500 ha (11,160 acres) within and adjacent to the Walter F. George Reservoir. The refuge, located approximately 9.7 km (6 miles) north of Eufaula, Alabama is bisected by the Chattahoochee River Valley and consists of 3,200 ha (8,000 acres) in Alabama and 1,200 ha (3,200 acres) in Georgia (U.S. FWS, no date).

The refuge is strategically located on the southeastern edge of the Mississippi Flyway and the southwestern edge of the Atlantic Flyway and was created as mitigation for the Walter F. George Federal Project to provide feeding and resting habitat for waterfowl migrating through the Tennessee Valley to the Gulf Coast. Impoundments and the waters of the Walter F. George Reservoir make up nearly half of the refuge acreage. The remaining acreage is upland areas consisting of agricultural land and forest. Farming is the primary waterfowl management practice providing wintering areas for large concentrations of ducks and geese. Agricultural lands are planted in corn, grain sorghum, and Japanese millet and are then flooded in late fall making the crops available to migratory waterfowl. Many other wildlife species are attracted by the diversity of habitat on the refuge (U.S. FWS, no date).

WATER PROJECTS/LAND AND WATER USE TRENDS

There are diverse land uses in the Chattahoochee River basin. Forest products, textiles and poultry production are major industries of the mountain region with recreation, tourism, and second home developments causing major land use changes.

The Atlanta and Columbus metropolitan areas are densely populated compared to other regions in the basin. The basin has little heavy industry but there is a significant amount of light manufacturing. Throughout the remainder of the Piedmont and Coastal Plain, land use is primarily agricultural with a growing dependence on irrigation where the necessary water resources are available (Georgia EPD, 1984a).

The Chattahoochee River is the predominate aquatic system in the Chattahoochee River basin. The river provides commerce (navigation), hydropower generation, recreation and water supply for the entire basin. The commercial use of the river is probably maximized as far as any expansion of the navigation channel, but commercial tonnage will probably continue to increase. Recreational activities along the river will continue to rise due to population and leisure-time increases. The Chattahoochee River will most likely not experience any major construction, except for a possible water-supply reregulation facility below Buford Dam. The basin may, however, experience an increase in the number of tributary impoundments for recreational activities.

The third major use of the river is water supply. There is a current proposal being studied by the Savannah District Corps of Engineers for a water supply/reregulation impoundment below Buford Dam. While the impoundment is under consideration, the Chattahoochee River, above Atlanta, Georgia continues to be the dominate source for potable water. Increase and expansion of agricultural practices in southwestern Georgia has resulted in ground water pumping for irrigation to have increased 200% between 1977 and 1981. A Georgia Geological Survey and U.S. Geological Survey mathemathical model to simulate future irrigation use shows aquifer discharge to streams will be reduced by 30% if withdrawals for irrigation continue to increase. This would substantially affect the base flow of the Chattahoochee and Flint Rivers in southwest Georgia (Radtke et al., 1980).

In summary, land use trends in the Chattahoochee River basin are not expected to change from their present use; only increased pressure can be expected. The same is true for water use, (industrial, commercial, recreation and water supply), all competing for the basin's waters. The Chattahoochee River basin has several options to abate future land and water-use problems. One option for both land and water use activities would be to establish realistic and accountable conservation measures. Poor land-use management precipitates either the abandonment of agricultural activities to other purposes (residential, industrial, etc.) or continues an agricultural practice that increases erosion. Without proper land-use management control of both these activities the net affect on the basin's water resources and its uses will be negative.

A second option is to limit or totally prohibit the habitation of undeveloped riverine floodplain lands. By enacting zoning restrictions to such lands, the growth of metropolitan areas can be controlled, directed, and planned to minimize adverse impacts to water resources. Third, the existing reservoir system should be evaluated to determine what can be done to increase their water storage capacity. Such action should be taken because there is a good possibility that for both economic and environmental reasons few, if any, impoundments will be completed on the Chattahoochee River. The demand for water for all purposes will continue to increase in the basin.

FLINT RIVER BASIN

OVERVIEW

The Flint River originates in the southern portion of the Atlanta metropolitan area and continues 550 km (340 miles) south to join the Chattahoochee River, forming Lake Seminole at the Florida line (Figure 4). The watershed encompasses 21,900 sq km (8,460 sq mi) and occurs in the Piedmont and Coastal Plain Provinces. The river is virtually unaltered except for three impoundments in the lower basin (U.S. COE, 1984b).

The headwaters of the Flint River begin in the Piedmont Province Region. Intrusions onto the river floodplain are few, except where overflow development from the Atlanta area occur and silviculture and pasturelands abut the river. The watershed in this area has a relatively unspoiled natural beauty with hardwood forests dominating upland habitats. The Flint River passes through the Pine Mountain District as it reaches the Fall Line area. The Fall Line is the transition zone between the Piedmont and Coastal Plain physiographic provinces. This section of the river is the longest reach of any Piedmont stream in Georgia that is practically unaltered by man. The Fall Line area characterized by the Pine and Oak Mountain ridges is heavily canopied, with a mixture of the southern Piedmont hardwoods, pine woodlands, and pockets of Appalachian mountain communities. Below the Fall Line the river flows into the Coastal Plain Province. Once primarily pine forested, the lands adjacent to the lower River have been converted to agricultural lands (Georgia DNR, 1976).

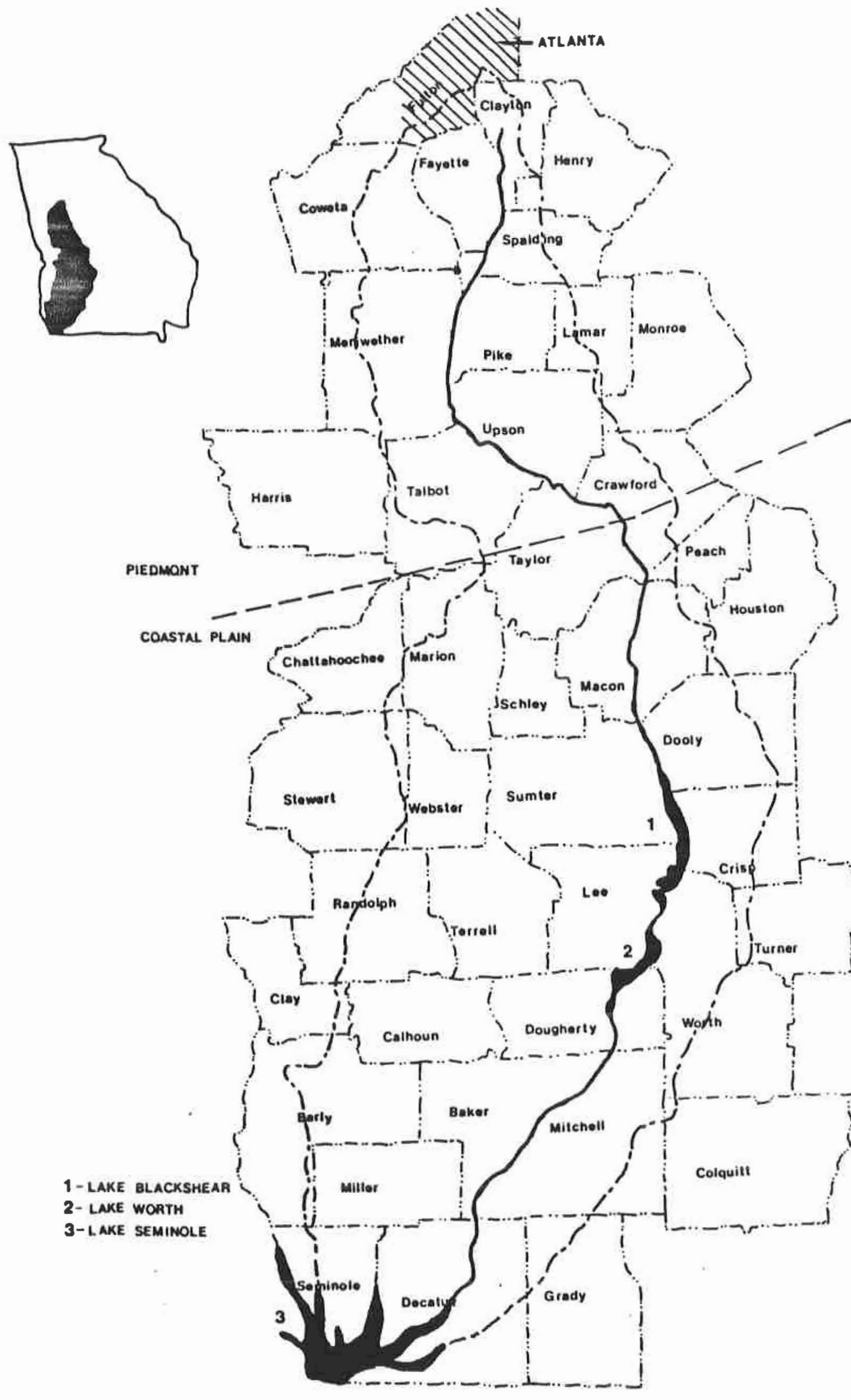
The Piedmont section of the river is considered by the Georgia Natural Areas Council as wild and scenic; is narrow with high banks, and typically colored brown by the Piedmont sediment. As the river enters the Fall Line it drops 152 km (500 feet) creating shoals, eddies, rapids and rock areas. As the Coastal Plain is reached, the river widens and the gentle gradient allows for broad bottomlands and swamps (Georgia DNR, 1976).

Floodplains and bottomlands along the Flint River are generally limited to the river banks because of topography and/or agricultural development. Floodplains in the upper river are heavily canopied with limited hardwood swamps. Floodplain vegetation is generally restricted to the river banks by urban development, agriculture and the rolling Piedmont topography. Species usually found consist of water hickory, overcup oak, sweetgum, river birch, sycamore, sugarberry, green ash, water oak, willow oak, and swamp chestnut oak with water tupelo, blackgum, and cypress, in pooled areas. Swamps only occur along the tributaries. Fall Line bottomlands are similar in composition to the vegetation found in the upper river. The vegetation consists primarily of oak, hickory, sweetgum, poplar, willow, maple, beech, sycamore, birch, and various pines. Swamps that occur on the Coastal Plain are dominated by cypress, tupelo, alder, blackgum and willow. Although more low-lying swamps occur on the Coastal Plain Province, agriculture usually abuts the river severely limiting bottomlands (Georgia DNR, 1976).

HISTORICAL/PRESENT UPLAND FORESTS

The American Indians began upland forest manipulation in the Piedmont Region of the Flint River with their agriculture and use of fire. As a result, in the late 1700's settlers reaching the region observed fields, second-growth forests and occasional stands of pines. The settlers then took over with cotton monoculture

Figure 4: Flint River Basin and Lakes and Impoundments.



until demand for cotton declined in the 1930's. The land then reverted to secondary forests and those predominantly pine forests were harvested for timber, pulpwood and used for naval store products (turpentine). These forest management practices hastened the return of the hardwood forests (Wharton, 1978).

Today, Piedmont Region forests along the Flint River consist of second growth deciduous hardwood and hardwood/pine mixtures. The probability of finding a virgin stand of hardwoods is remote (Wharton, 1978). Dominate hardwood species consist of scarlet oak (Quercus coccinea), black oak (Quercus velutina), southern red oak, and chestnut oak, co-dominants include shagbark hickory, longleaf pine, pignut hickory, sugar maple, and sweetgum. Subcanopy dominants consist of dogwood, eastern red bud, red mulberry, sourwood, red maple, winged elm, sparkleberry, and Georgia hackberry. The shrub layer includes such species as blueberry and paw paw. Although relatively scarce, herbs to be found are muscadine grape, greenbriers, mint, wintergreen, goldenrod, and asters (Georgia DNR, 1976; Wharton, 1978).

While hardwood forests predominate in the Piedmont upland, needleleaf evergreen forests predominate on the Coastal Plain. These forests were also altered by Indian agriculture (corn) and the white man (cotton). Today's forests are pine and/or pine-hardwood mixtures. The forests were originally longleaf pine, but are now mixed with slash pine, shortleaf pine, and loblolly pine. The forest have little to no sub-canopy, although southern red oak is sometimes found. Shrubs and vines consist of gallberry and runner oak. The ground cover varies with location but usually includes wiregrasses, flea-bane, deer tongue, gold aster, sunrose, wild indigo, gopher apple and cone flower. In the lower Coastal Plain the "pine flatwoods" are long-leaf, slash or pond pine with a heavy shrub ground cover of saw palmetto, gallberry, blueberry and dwarf oak. The pine/ hardwood forests consists of shortleaf pine, mockernut hickory, red oak, black oak, post oak, and dogwood (Georgia DNR, 1976; Wharton 1978).

Exceptions to the usual upland forests along the Flint River occur in the Pine Mountain/Oak Mountain ridgeline and Sand Hills/ Talbotton Corridor. Both areas occur just north of the Fall Line between the Chattahoochee and Flint Rivers. The Pine Mountain/Oak Mountain area has the typical Piedmont hardwood and pine forests but with pockets of Appalachian mountain communities interspersed within the area. This area along the Flint includes the well known Sprewell Bluff site. The Sand Hills/Talbotton Corridor exhibits both characteristics of Piedmont and Coastal Plain vegetation communities. The forests are heavily wooded whether hardwood or pine with deeply cut ravines running to the creeks and rivers. This area combines features of both regions and is therefore not easily classified (Georgia DNR, 1976).

The Flint River basin upland forests (hardwood and/or pine) currently provide good habitat for wildlife species, especially in the upper basin. Hardwood forests are important as wildlife habitat, particularly when mast-producing species such as oak and hickory are numerous, and the understory provides browse for deer. The mast-producers not only provide winter food for deer, but also are a prime food source for squirrels. Important deer browse species include honeysuckle, greenbriar, ivy, grape, dogwood, blueberry, and farkle-berry. The hardwood forest also provides habitat for songbirds, owls, and hawks. Some hunting by carnivores such as fox, weasel, and mink takes place in the forest, though the bottomlands are more likely to have more usage, particularly by mink (Elias, 1980; Stokes, 1981).

Pine dominated forests provide habitat for a variety of wildlife, especially birds. Owls utilize the pines for cover; cavity-nesting birds inhabit mature pines as do pine warblers and other songbirds. Pines also provide food, shelter and habitat for the fox squirrel and other small mammals. The deciduous understory, if present, such as oak and hickory provide mast for wildlife such as deer and squirrels. The understory is an important provider of browse for wildlife. The actual wildlife productivity values and diversity that the evergreen forest provides are dependent on whether it is natural or planted. Evergreen forests in natural succession usually provide a greater diversity of food sources and cover than intensively managed pines plantations (Elias, 1980; Stokes, 1981).

The hardwood/pine forest provides a more balanced habitat for fish and wildlife, depending on forest maturity and condition. The pines provide habitat for cavity-nesting birds as well as habitat for songbirds. The hardwoods provide mast food for large game and for small mammals like the gray squirrel. Both kinds of trees provide shelter and habitat for small mammals (Elias, 1980; Stokes, 1981).

Upland forests are one of the main habitats found along the Piedmont region of the upper Flint River. Except where agriculture and a few residential areas occur, the forests line the river. In the Coastal Plain forested areas are greatly reduced by agriculture (crops, grazing, silviculture) which border the river. Intensively managed pine plantations probably make up a majority of the so-called upland pine forests (Costa, 1985b; Georgia DNR, 1976; Middle Flint APDC, 1978a, 1978b; Mixon, 1985; Seleb, 1985a).

URBAN AREAS

The Flint River basin is essentially rural in nature, with few urban areas scattered along the system; however, urban areas in the headwaters are experiencing growth due to "spillover" from Atlanta. There are no major cities on the upper river after it leaves the Atlanta area. Some of the larger cities are Griffin, Newnan, and Peachtree City, with populations of 20,728, 11,449 and 6,429 respectively. In the middle basin, there are no major cities on the river, except for Oglethorpe and Montezuma with populations of 1,305 and 4,830 respectively. The cities of Albany and Bainbridge, located on the river, dominate the lower basin. Albany has a population of 85,000 and Bainbridge near 10,553 (Rand McNally, 1987; Univ. of FL, 1987).

Generally, urban areas located on the river impact the system by direct development of the river banks and floodplains. In addition, the use of the river for domestic and industrial water supply can alter normal flows if a minimum flow is not maintained. Discharge of inadequately treated domestic or industrial wastewaters may degrade the integrity of the river system. In the upper basin, the headwaters of the Flint are severely degraded from construction activities and wastewater discharges. Other disturbances to the river in this section mainly result from water supply withdrawals for existing communities (Georgia EPD, 1984b; U.S. COE, 1985a, 1985b).

Urban development in the middle basin has had relatively little impact on the river system, due mainly to Georgia's rigorous program of wastewater treatment by industries and municipalities. Buckeye Cellulose Company in particular, has upgraded facilities reducing impacts to Lake Blackshear (Georgia DNR, 1984b).

In the lower basin, most impacts from urban centers to the system occur from wastewater discharges into the river, although this area is also under a rigorous water quality control program. The cities of Albany and Bainbridge impact the river by general development along its banks, and Albany occasionally experiences wastewater treatment problems such as elevated fecal coliform densities in the river. Generally, quality of water from urban areas has greatly improved from previous years (Georgia EPD, 1984b; U.S. COE, 1985a).

AGRICULTURE

Agricultural lands (crops, pasture, siliviculture) abut the Flint River over most of its length, except near Atlanta where urbanization has occurred. Because of the topography agriculture is more extensive in the Coastal Plain Region than in the Piedmont Region (Georgia DNR, 1976).

Agricultural lands in the upper Flint River consist mainly of siliviculture and livestock rangeland. There is also a small amount of grain production (McIntosh Trail APDC, 1985). At the Fall Line there are large areas of managed timberlands, but they occur interspersed with the hardwood forests presenting a more natural look than in other agricultural areas.

Below the Fall Line, pine plantations become the prevalent siliviculture operation (Georgia DNR, 1976). Crop producing lands in the middle Flint River occur mainly on the east side of the river where the soil is most fertile.

Crops produced are corn, soybeans, peaches, pecans, cotton and peanuts. Cotton production has been decreasing while soybean production has increased. Poultry and livestock production occurs on a smaller scale (Middle Flint APDC, 1978a; Costa, 1985).

Agricultural lands along the lower Flint River are dominated by siliviculture, livestock rangeland and pecan orchards. Rowcrop agriculture of predominantly cotton, soybeans, and peanuts make up most of the remaining agricultural lands (Richards, 1985).

Agricultural lands adjacent to the Flint River have significantly impacted the river system along most of its length. With a majority of agriculture abutting the river, the floodplains and swamps have been reduced to the river banks. Agricultural lands also do not provide as optimum a habitat as do bottomland hardwoods and upland hardwood and/or pine forests.

WATER QUALITY

The water quality of the Flint River has greatly improved and is now in compliance with designated water use classifications. Since 1964 the Georgia Department of Natural Resources, Environmental Protection Division (Georgia EPD) has had a rigorous water quality control and monitoring program that has upgraded and stablized the water quality (Georgia EPD, 1978, 1984b).

From its headwaters to Georgia S.R. 54 the river is degraded by urban runoff, construction activities, and treated domestic and industrial wastewaters from

the Atlanta area and is designated as "Fishing"[1] by the State of Georgia. The present designation is an improvement and has been upgraded from the "Industrial"[1] designation of a few years ago. This section of the Flint River had been receiving diverted waters from the Chattahoochee River used for wastewater treatment. The completed Atlanta Three Rivers project has helped improve water quality in the headwaters by removing from the Flint River the discharge of Atlanta's Flint River Water Pollution Control Plant (Georgia EPD, 1978, 1984b; U.S. COE, 1987).

Below S.R. 54 to Woosley Road (S1061), the river is also classified as "Fishing"; water quality is still degraded in this section but does not receive the nutrient loads as it does upstream. From Woosley Road to the Georgia Highway 16, the river is designated "Drinking Water"[1]. From Highway 16, to Georgia Highway 27 (Lake Blackshear) the river is designated "Fishing"[1]. Georgia EPD reports the improved water quality and compliance with conditions of its water use classifications. Of special significance and interest are water color reduction by Buckeye Cellulose Company and upgrading of facilities at Montezuma. From Georgia Highway 27 to the Georgia Power Company Dam at Lake Worth the river is classified as "Recreation"[1]. The river is classified as "Fishing"[1] from Lake Worth to U.S. Highway 84 where Georgia EPD reports that in the Albany area improvements have been made to the WPCP, and monitoring data from 1982 revealed that the river is in compliance with its classification, except for occasionally elevated fecal coliform bacterial densities (Georgia EPD, 1978, 1984b).

From U.S. Highway 84 to Bainbridge to Jim Woodruff Dam, Lake Seminole the river is classified as "Recreation"[1]. Urban runoff and wastewater discharges from Bainbridge also create occasional elevated fecal coliform densities in this section of the river (Georgia EPD, 1978, 1984b).

STREAMS AND FLOODPLAINS

The Flint River is Georgia's sixth largest river having an average flow of 8,850 cfs and a drainage area of 21,900 sq km (8,460 sq mi) at its mouth. The river basin is characterized by the geological province it occurs in. The river begins in the Piedmont Province passes through the Fall Line and ends in the Coastal Plain Province (Georgia EPD, 1984b).

Due to the low water-bearing nature of the rock in the Piedmont Province the river derives its flow from precipitation, feeder streams and local run-off. Three of the major tributaries to the upper Flint River are Line Creek, Elkins Creek, and Potatoe Creek. The upper Flint is a typical Piedmont stream having three general appearances: shoals, sometime with whitewater and falls; the gently meandering slower runs and the strongly meandering slow water. The river is colored brown due to the sediment-carrying capacity of the water (Georgia DNR, 1976; Georgia EPD, 1984b).

Piedmont floodplains are usually found to be less than 0.8 km (0.5 miles) in width and may border one or both sides of the river, and are restricted to the river borders by topography or agriculture. Lowland swamps are usually found at the mouths of the small tributaries. Floodplain vegetation generally consists of red maple, sweetgum, water hickory, swamp chestnut oak, water oak,

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1 See Appendix I for water quality designation criteria.

willow oak, overcup oak, river birch, green ash, with tupelo and cypress in the pooled areas. The understory includes dogwood, possum haw, Kalmia sp., holly, silverbell, and red buckeye (Georgia DNR, 1976).

Beginning at the Fall Line ground water becomes plentiful and contributes an increasingly larger portion of the river's total flow. The river and creeks carry sediment and appear muddy to light brown in color depending on their soil origin. At the Fall Line, mountains and ridges rise 122 to 275 m (400 to 900 feet) above water level. Rock outcroppings are common, boulders and islands are scattered and the river is characterized by eddies, thundering rapids, and quiet pools (Georgia DNR, 1976; Georgia EPD, 1984b).

The Georgia Natural Areas Council has said the upper portion of the Flint River is "undoubtedly the most scenic stream in the Georgia Piedmont". The vegetation in this area is considered unique because of the combinations of vegetation (Piedmont, Coastal Plain, Mountain) not in existence elsewhere in the State (Georgia Conservancy, 1974). Floodplain vegetation at the Fall Line consists of oak, hickory, sweet gum, poplar, yellow poplar, willow, maple, beech, sycamore, river birch, and various pines (Georgia DNR, 1976).

As the river flows southward into the Coastal Plain Province it becomes larger with inflow from numerous tributary streams and groundwater. The gradient is flat such that marsh and black water low-lying swamps become more prevalent along the stream course. Major creeks below the Fall Line and in the Coastal Plain are Whitewater, Buck, Muckalee, Spring, Kinchafoonee, and Ichawaynochaway Creeks. The substrate of the lower river is composed of Ocala limestone outcroppings and rubble. The average gradient between Lake Blackshear and the City of Albany is 3.25 m per km (1.6 ft per mi). Below Albany to its mouth, the fall of the river is 2 m per km (1 ft per mi) although there are areas of steeper gradient (Pasch, 1976). The stream is characterized by long sections of slow moving, deep water alternating with shoals composed of limestone rubble and sand. In the section below Albany, many islands and wing dams constructed of rubble and boulders as navigation aids provide habitat diversity (Pasch, 1976).

The Coastal Plain floodplain of the Flint River can be divided into two types, those inundated more than six months per year and those inundated about or less than six months. The first type supports bald cypress and black gum. These trees occupy the lowest areas of the floodplain including all waterways, many with more or less permanent standing or flowing water. Other tree species found in association include alder, red maple, and carolina ash. The second type of floodplain is a bottomland hardwood forest consisting of willow, cottonwood, silver maple, river birch, overcup oak, water hickory, sugarberry, laurel oak, red maple, American elm, green ash, and sweetgum. The marsh vegetation is dominated by sawgrass (Cladium jamaicense) (Wharton, 1978).

The floodplain or bottomland habitat supports a diverse and productive biota adapted to alernating high and low water flows. This fluctuation produces annual fertility and life pulses as a result of the decomposition of organic material caused by alternate wetting and drying, the action of the biota, and an influx of mineral nutrients brought in as silts or clays (Wharton, 1978).

Some Piedmont floodplain food chains involve autotrophic (largely periphyton) primary producers, but most appear to be based principally on detritus decomposers. Following detrital decomposition on floodplain surfaces; winter and spring high water flush the nutrients into the mainstream and into downstream communities along with many of the floodplain organisms. This particulate matter and organisms flushed into oxbows, pools, and river channels and redistributed over the floor of the floodplain forest constitute a nutrient pulse that is undoubtedly important to the various trophic levels of the ecosystem. These nutrients pulses appear to be followed by pulses in living biomass, in such things as benthic macroinvertebrates and fish. Another characteristic, complimentary to the nutrient pulses, is the overbank deposition of silt and clay. Such action helps to bind and enrich sediments for the expanded use of floodplain flora and fauna (Wharton, 1978).

The slow-moving floodplain sections of streams have important value in maintaining water quality and quantity, producing animal products, and in the stabilization and use of silt and clays accumulated from silviculture and urban activity on the uplands. The bottomland acts as a natural regulator of water quantity, as a filter for pollutants and toxins, and an upland-water interface for fish and wildlife species (Wharton, 1978).

The Piedmont floodplains support a variety of fauna. In early spring, enormous numbers of mayflies, isopods, crustaceans, amphipods, and oligochaete worms are found. Salamanders, anoles, skinks, toads and frogs abound, while snakes are rare and turtles are common. A wide variety of mammals utilize the area such as otter, mink, raccoon, muskrat, shrew, mice, rabbit, beaver and deer. Large numbers of warblers, flycatchers, kingbirds and woodpeckers also are found. Robins, waxwings, and blackbirds pass through the swamps during migration. Hawks and owls feed along the floodplains. Some waterfowl winter in the swamps and nest there in the spring (Wharton, 1978).

The Coastal Plain floodplains are predominantly swamp systems having longer periods of inundation. Studies indicate that river swamp systems are more productive than temperature deciduous forests. A general picture of swamp floor productivity is as follows: during the first four months after leaf fall, leaves gain nitrogen (from bacterial growth). Following this, there is a dense growth of filamentous algae which recycles nutrients until the forest floor becomes dry and shady at spring leaf-out time, when billions of tiny tree rootlets, along with extensive mycorrhizal fungi take over the nutrient absorption. There thus appears to be a continuous mechanism for the removal of nutrients from the floodplain floor. The sheet flow of the high water sweeps both dissolved and particulate organic material into the main stream as well as into downstream oxbows and water courses of all types. It also sweeps floodplain floor organisms along with it, leading to a vast augmentation of food for the life in the river. Considerable amounts of particulate organic matter in Coastal Plain rivers may originate on the floodplain during periods of high water (Wharton, 1978).

The river bottom swamps of the southeast are of high value to the ecology of the rivers because of the fluctuating water levels over the floodplain. This periodic inundation of the floodplain plays a vital role in the area of fish production. The floodplain benthos production is 15 to 20 times greater than the channel, and the potential of floodplain benthos production is from 300 to 500 times greater than the riverbed. High production, however, never

materializes because of fluctuating water levels. Following a sustained wet cycle "bumper crops of large fish are reported from Coastal Plain streams". Lower Coastal Plain streams are more variable in their water level fluctuations than are those whose headwaters lie in the Piedmont or upper Coastal Plain (Wharton, 1978).

The floodplain/swamp contains many sloughs, oxbows, and interconnected channels. These areas are important as spawning and nursery areas. Floodplain pools and lakes that become overpopulated during low water serve as feeding grounds for predatory river fish at high water; species such as bass, pickerel, bream, and other fish leave the channel and forage among the floodplain floor (Wharton, 1978).

Some geologists believe that the rivers may recharge the principal underground aquifer when they cross the zone of the upper Coastal Plain. Just above this zone are the very wide swamps reaching up to the Fall Line. These large swamps serve as natural reservoirs and may affect low water flows through the aquifer recharge zone. High water inundations on the floodplains do aid, however, in maintaining higher water tables in agriculturally important shallow aquifers and in permeable soils adjacent to the streams and floodplains of the Coastal Plain (Wharton, 1978).

The Coastal Plain floodplains also supports a diverse fauna. Invertebrates include mites, springtails, beetles, flies, amphipods, copepods, and crayfish. Amphibians are plentiful, frogs, salamander, waterdogs, conger eels, newts, and skinks frequent the area. Alligators, turtles, cottonmouth and diamondback rattlesnakes and other water snakes are floodplain and swamp residents. Mammals to be found include deer, gray fox, skunk, bobcat, rabbit, coyote, raccoon, opossum, otter and beaver. A rich variety of birds are observed too, yellow-crowned night heron, blue heron, spotted sandpiper, white ibis, red-shouldered hawk, red-tailed hawk, belted kingfisher, woodpeckers, woodduck, warblers, and kites have been reported from the floodplains (Wharton, 1978).

LAKES AND IMPOUNDMENTS

Lake Blackshear

Lake Blackshear is located in the middle Flint River basin 53 km (33 mi) above the City of Albany at RM 136, and is bounded by Crisp, Lee, Worth, Sumter and Dooly Counties (Figure 4). The Lake was created as a reservoir for hydroelectric power by the Crisp County Power Commission and has been in operation since 1930. Recreation is a secondary use. It is a run-of-the-river facility, and has a water surface of approximately 3520 ha (8,700 a), is approximately 24 km (15 mi) long and has an average width of 0.5 km (0.75 mi). The lake has approximately 124 km (77 mi) of shoreline and an average depth of 6.3 m (20 ft) (Weaver, 1979).

Approximately 36.5% of the lands surrounding the lake are residential. Land devoted to commercial use is sparse and accounts for 1.4%, the businesses being either marinas, fish camps or bait and tackle shops. Fish and wildlife preservation areas represent approximately 1.7% of lands bordering the lake. These lands include wetlands, swamps, or other sensitive ecological communities, and although currently designated as preservation areas, they are not permanently set aside for habitat preservation. Crisp County Power Commission owns 0.6% of the land for use in electrical power production. Recreational lands make

up 7.5% and most are publicly owned, consisting of State parks, County parks, and boat ramps. Agricultural and forest areas comprise 52.6% and include cropland, pasture, cleared lands, and lands covered with trees (but not necessarily under forestry practices) (Middle Flint APDC, 1978b).

Lake Blackshear has been studied by the Georgia Game & Fish Division more than any other reservoir in southwest Georgia, with fisheries data collected as early as 1950. Cove rotenone samples have been collected since 1954 with creel surveys conducted from 1959 through 1971 with the exception of 1964, 1966, and 1968. More recent creel surveys and population sampling occurred in 1974-76 and 1977. Fish species generally found in the lake include largemouth bass, bluegill, crappie, sunfish, pickerel, catfish, suckers, gars, shad, minnows, and darters. Many species of fish have been stocked in the lake; threadfin shad and white bass were stocked in 1959, striped bass in 1967-1969, largemouth bass in 1974-1977, and bluegill and channel catfish in 1976 (Weaver, 1979).

In the 1950's, fishing in Lake Blackshear was considered poor by local fishermen. In 1958 fishermen and local citizens asked the then Georgia Game and Fish Commission to help improve fishing in the lake. Gizzard shad were found to be in such abundance that they had virtually taken over the lake. After chemical treatment for the rough fish was accomplished, fishing became "good" in the lake (Georgia DNR, 1960). From 1959 to 1971, crappie was the number one species sought after and harvested. The second most sought after fish was the largemouth bass with bluegill, white bass, and channel catfish contributing significantly to the creel. However, annual total harvest decreased by half from 1965 to 1977. Crappie was also the most sought after species in 1975 and 1976, a decrease in crappie fishing pressure was noted in 1977 (this may have been due to creel clerk error). Largemouth bass continued to be the second most sought after fish species with only a small decline by 1977. However, "fished for" pressure for sunfish and channel catfish also exhibited a decline by 1977. From 1975 through 1977 the majority of fishing occurred in the spring with 40% from March through May with peak fishing effort in mid-spring and late summer (Weaver, 1979).

Although the overall harvest was low, the quality of the Lake Blackshear fishery was about equal to or slightly better than that found on other Georgia reservoirs in 1976 and 1977. Reservoirs included in the comparison were Westpoint Reservoir and Lake Walter F. George (Chattahoochee River basin), and Lake Sinclair (Oconee River basin). Unfortunately total harvest estimates for Lake Blackshear did not include that which occurred during nocturnal periods which could have been more significant than that from other reservoirs. Many bass clubs hold tournaments at night and crappie fishing with lanterns is popular (Weaver, 1979).

Beginning in 1980 striped bass hybrids have been stocked into Lake Blackshear. A total of 710,759 hybrids have been stocked. Striped bass were stocked in the lake from 1967 until 1972. A total of 117,842 fish were stocked (Georgia DNR, 1987).

<u>Lake Worth</u>

Lake Worth is located in the lower Flint River basin at RM 104 approximately 3.2 km (2 mi) above the City of Albany (Figure 4). The lake was created by the Georgia Power Company for hydroelectric power generation and consists of two dams, one on Muckafoonee Creek constructed in 1906 and the other on the Flint River constructed in 1921 (U.S. COE, 1978a).

The lake has a surface acreage of approximately 1,011 h (2,500 a) with sawgrass islands and shaded streams. Fish found in the lake include bass, sunfish, bluegill, crappie, catfish and pickerel. Stocking of white bass and threadfin shad has also occurred in the lake.

During the late 1950's the Georgia Game and Fish Commission began chemical treatment and study of Lake Worth to improve fishing. After treatment in 1957, sampling showed the fish composition to be 54.8% game and 45.2% rough showing a domination of bluegill, particularly redear sunfish, largemouth bass, crappie, redbreast sunfish, and channel catfish. Spring was the best season for fishing (Georgia DNR, 1957). Later sampling by the G&F also indicated that fishing was still "good" on Lake Worth (Georgia DNR, 1970b, 1980 and 1981). No creel surveys have been accomplished on the lake, so fishing pressure information is unavailable. The lake is also utilized heavily for other recreational boating activities.

Lake Seminole

Lake Seminole formed by the confluence of the Flint and Chattahoochee Rivers behind Jim Woodruff Lock and Dam has been discussed previously in the Chattahoochee River basin portion of this report.

RIVERINE FISHERY RESOURCES

The known freshwater fish fauna of the Flint River comprises 18 families and 83 species (Table 1). A greater diversity is found above the Fall Line than below. Seven species of fish are reported as endemic to the ACF River basin and all are represented in the Flint River (Table 2). The entire Flint River is considered to support a warm water fishery, such that the physiographic differences of the available aquatic habitats determines the characteristic fish fauna (Table 3) (Martin, 1973; Molley, 1970).

The river fishery has been extensively studied. Georgia Game and Fish Division conducted sampling in 1971 by rotenone sampling and electrofishing on the river in Upson County. The most abundant fish species based on weight per acre were found to be flathead catfish, gizzard shad, snail bullhead, and shoal bass (McSwain, 1972).

Georgia Game and Fish Division conducted a creel survey from July 1974 through June 1975 on the upper Flint River (Section I: GA Hwy. 16 to GA Hwy 36 and section II: GA Hwy 36 to GA Hwy 128). Section I had the highest fishing pressure and greatest harvest. In order, the fish caught in greatest numbers included redbreast sunfish, bluegill, suckers and shoal bass. Bank fishermen accounted for the majority of the fishing trips and harvest. Weekday fishing was the most common time of fishing. Also, most of the fishermen were seeking all species, while only a small percentage were fishing exclusively for shoal bass (Ober, 1977).

Section II had a much lower fish harvest than Section I but the species taken in order of greatest catch were the same. Fishing pressure was only half of that occurring in Section I. Although bank fishermen accounted for more of the fishing trips, boat fishermen caught more fish. Also, a smaller percentage of Section II than Section I fishermen were seeking all species while a higher percentage were seeking bass (largemouth and shoal) (Ober, 1977).

A recreational survey also taken during the same period cited 30,500 trips/year for fishing in Section I and 13,500 trips/year for Section II. Total annual pressure for all types of fishing in the study area was 44,000 trips/year with 82.6% originating in the surrounding counties compared to 10.4% originating from the Atlanta area. A common complaint of the local residents was that most of the access to the river was being bought or leased by private clubs or individuals, most of whom were from the Atlanta area (Ober, 1977).

The overall fishing pressure for the upper Flint during this period was much higher than that on the lower Flint River and the upper and lower Satilla River (southeast Georgia) surveyed during the same time period (1972-1975). The per unit area pressure was also greater than that found on Lake Jackson (north central Georgia), the most heavily used reservoir surveyed during the American Fisheries Society, Southern Division's predator-stocking-evaluation study (Pasch, 1976).

Most recently the Georgia Game and Fish Division conducted a survey of the fish population and sport fishery in the upper Flint River during nine months in 1984 (Ellis and Clark, 1986). The portion of the river surveyed was from the Gay-Flat Shoals Road (southeast of Gay) to Georgia Highway 128 (northeast of Butler). The study area was 91.7 km (57 miles) in length. The lower boundary used in the study was the same as in the earlier study by Ober (1977), however the upper boundary was changed to exclude a portion of the river that has dissimilar physiographic characteristics (Ellis and Clark, 1986).

In order, the fish recreationally caught in greatest numbers included sunfish (mostly redbreast), shoal bass and catfish. The most notable change in the upper Flint River fishery since the mid 1970's was the 86% decrease in the total harvest. Further, the total fishing pressure decreased 49% since the earlier study. The proportional decrease in harvest from the earlier study was much greater than the drop in fishing pressure. This indicates that changes in harvest were probably not due entirely to changes in fishing pressure. The type of anglers and their fishing methods have changed in the upper Flint River since the mid 1970's from predominantly bank fisherman using still fishing methods and natural bait to boat fisherman using cast, spin or fly fishing methods and artificial bait. This alteration in the dominant fishing method, as well as in the decline in total fishing pressure, may have occurred because of the reduction in access. Approximately one-third of the access roads open to the public during the earlier study were closed by 1984, and thus had become inaccessible to most bank anglers. Conversely, boating access has been improved with the addition of three public boat ramps (Ellis and Clark, 1986).

Data from the upper Flint River 1984 survey was compared to other studies on Georgia streams. The total pressure and overall catch rate were lower than similar estimates from all other studies. Overall success for redbreast sunfish was similar to those observed on the lower Flint River and on the Satilla River, but lower than those observed on the Ocmulgee River and the previous mid 1970 survey. The annual catch rate for all catfish species was similar to all other studies except for the earlier upper Flint River study which was much higher (Ellis and Clark, 1986).

Georgia Game and Fish Commission (now Division) also in 1970 and 1971 sampled the lower river below Albany at RM 91 by electrofishing and rotenone sampling. The most abundant species occurring, based on weight per acre, were snail bullhead, catfish, gizzard shad, carp, spotted sucker, redbreast sunfish, and longnose gar (McSwain, 1972).

Table 2: Fish Species endemic to the ACF River basin occurring in the Flint River basin. Martin, 1973.

Common Name	Scientific Name
Bluestripe shiner	*Notropis callitaenia*
Highscale shiner	*Notropis hysilepis*
Broadstripe shiner	*Notropis euryzonus*
Bandfin shiner	*Notropis zonistius*
Greyfin redhorse	*Moxostoma* sp. c.f. *M. poecilurum*
Greater jumprock	*Moxostoma lachneri*
Shoal bass	*Micropterus* sp. c.f. *M. coosae*

Not endemic to ACF according to Lee et al

Table 3: Distribution tendencies found in the Flint River basin for fish species. Martin, 1973.

Species found above the Fall Line restricted to the Piedmont Province on the Flint River.

Campostoma anomalum
Ericymba buccatu
Nocomis leptocephalus
Noxostoma rupiscartes
Notropis lutipinnis
Notropis sp. c.f. *bellus*
Erimyzon oblongus

Species found below the Fall Line, found or reported only on the Coastal Plain on the Flint River.

Lepisosteus osseus
Amia calva
Alosa chrysochloris
Dorosoma petenense
Hybopsis harperi
Notropis chalybaeus
N. hypselopterus
N. maculatus
N. petersoni
N. welaka
Erimyzon sucetta
Ictalurus serracanthus
Noturus gyrinus
Fundulus chrysotus
Elassoma evergladei
E. zonatum
Enneacanthus gloriosus
Lepomis marginatus
Mugil cephalus

Species collected below and slightly above the Fall Line of the Flint River (penetration of restrictive topography).

Dorosoma cepedianum
Notropis culmmingsae
N. euryzonus
Fundulus notti
Etheostoma edwini

Species found throughout the Flint River drainage.

Ichthyomyzon gagei
Esox americanus
E. niger
Hybopsis sp. c.f. *H. winchelli*
Notemigonus drysoleucas
Notropis callitaenia
N. emiliae
N. longirostris
N. texanus
N venustus
Semotilus atromaculatus
Minytrema melanops
Moxostoma sp. c.f. *M. poecilurum*
M. lachneri
Ictalurus brunneus
I. natalis
I. nebulosus
I. punctatus
Noturus leptacanthus
Aphredoderus sayanus
Gambusia affinis
Labidesthes sicculus
Ambloplites rupestris ariommus
Centrachus macropterus
Lepomis auritus
L gulosus
L. macrochirus
L. punctatus
Micropterus sp. c.f. *M. coosae*
M. salmoides
Pomoxis nigromaculatus
Etheostoma fusiforme
E. swaini
Percina nigrofasciata

Further, Georgia Game and Fish Division conducted a creel survey from June 1973 to June 1975 on the lower river between Lake Blackshear and Newton, Georgia. The survey had two sections, Section I: from the tailwaters of Lake Blackshear to the headwaters of Lake Worth and Section II: from the tailwaters of Lake Worth to Newton, Georgia. Generally, from 1972 to 1975 increases occurred in fishing pressure and harvest. Both tailwaters of Lakes Blackshear and Worth received the greatest fishing pressure and harvest (Pasch, 1976).

Bluegills were harvested the most for the four year period with redbreast sunfish and channel catfish following. Largemouth and shoal bass harvest was erratic throughout the 1972-75 survey, harvest by numbers was never significant compared to the total creel. Bullhead catfish were harvested in significant numbers. The white bass fishery was cyclic, reflecting the strength of the run of this species to the Lake Worth tailwaters (Pasch, 1976).

Section II received 2.5 times more pressure and produced 2.5 times more fish than Section I. This unequal pressure and harvest was due to the population concentration at the City of Albany on the lower section, and more limited access to the upper section. The river below Lake Worth was probably capable of sustaining a heavier fishery than the upper section because of organic enrichment from the City of Albany wastewater treatment plant (Pasch, 1976).

From 1973 to 1974 bank fisherman exerted the most fishing pressure but accounted for a smaller percentage of the catch than boat fishermen on the entire survey area. Fishing pressure exerted on weekdays compared to weekends, was practically equal. The 1974-1975 survey showed that boat fishermen accounted for a greater percentage of all fishing pressure than in previous years but harvested a smaller percentage of the total catch than in any previous year. Weekend versus weekday fishing did not differ significantly from previous years. The lower Flint River's fishing pressure and harvest per unit area compares favorably with Lakes Jackson and Sinclair (east central Georgia), two of Georgia's most heavily fished reservoirs (Pasch, 1976).

During a Georgia Game and Fish Division 1973-1976 lower Flint River survey, three rotenone population samples were collected during 1973 and 1974. Of the predatory game fish, largemouth bass were predominate; of non-predatory game fish redbreast sunfish were dominate with bluegill following. Snail bullhead made up the largest percentage of the non-predatory food fish with spotted bullhead coming in second. In the predatory food fish group, channel catfish dominated the sample with white catfish following. Gizzard shad composed the majority of the forage fish population sample, with threadfin shad following. Of the entire population sampling non-predatory food fish made up a greater part of the standing crop than any other group (Pasch, 1976).

The mid-1980's has shown an increase in recreational fishing for striped bass in the lower Flint River and Lake Seminole. The striped bass population there provides a unique trophy fishery that has a potential to produce a new all-tackle world record striped bass. Three line test catagory world records recognized by the International Game Fish Association are held by fish caught in the Flint River at Albany (International Game Fish Association 1985) (Keefer, 1986).

The river also supports a commercial fishery for catfish. In order of preference the following species are taken: channel, white and bullhead catfish. There is also a fishery for the flathead catfish, introduced into the Flint River system by commercial fishermen. For the 1984 year, 584 individual commercial fishing

licenses were issued by the Georgia Department of Natural Resources, in the counties adjacent to the Flint River. Numbers of licenses per county ranged from 0 to 291, Decatur and Seminole Counties having the highest number of 291 and 101 respectively (Hughes, 1985).

MOLLUSCAN FAUNA

The Apalachicola River drainage (of which the Flint River is part of) contains the greatest total number of mollusk species, the largest number of endemic species, and the largest number of species endemic to any single one of the drainage systems.

The Flint River system once had an abundant molluscan fauna, however habitat alteration (agriculture, industry, pollution) of the drainage basin has caused extirpation or reduction of many resident populations. The Flint River's population is currently in better condition than the Chattahoochee River which has undergone drastic alteration in the form of dams/reservoir construction. The following mollusks are in jeopardy on the Flint River (U.S. Fish and Wildlife, 1975): Diominate pearly mussel, (Lamsilis binominata), Cedar Creek snail, (Marstonia castor), Flint River snail, (Somatogyrus catanotus), Potato Creek snail, (Somatogyrus rheophilus), Torrential snail, (Somatogyrus torrens), Recovery pearly mussel, (Elliptio nigella), Vienna river snail, (Goniobasis viennaensis), Albany river snail, (Goniobasis albanyensis), Elliptoid pearly mussel, (Elliptio sloatianus), and Parallel-ridged mussel, (Megalonaias neisleri).

Unfortunately current or updated information is unavailable. As with most fish and wildlife issues today, information is not collected or generated until a species is threatened by some type of habitat alteration such as dam/reservoir construction.

WILDLIFE RESOURCES

The Flint River basin provides good quality habitat for wildlife. The relatively sparse development along the river (except for agriculture in the Coastal Plain) is a major factor in the support of wildlife populations.

Wildlife abounds in the Piedmont floodplains. The two-lined salamander (Euryea bislineata) and three-lined salamanders (E. longicauda guttolineata) are the most commonly encountered amphibians. The marbled salamander (Ambystoma opacum) is spotty in distribution and the showy spotted salamander (Ambystoma maculatum) is confined to higher terraces while the southern dusky salamander (Desmognathus auriculatus) is locally abundant in very moist places. The species rarely occurring are the two red salamanders (Pseudotriton ruber and P. montanus) and the four-toed salamander (Hemidactilium scutatum). Of the frogs, the bull (Rana catesbeiana), green (R. clamitans), and cricket (Acris gryllus) frogs are most common. The spring peeper (Hyla crucifer) becomes locally abundant only at breeding time and the leopard frog (R. sphenocephala), American toad (Bufo americanus), and narrow-mouthed frog (Gastrophyne carolinenesis) are encountered occasionally. The most common reptile is the box turtle (Terrapene carolina). Painted turtles (Chrysemys picta) are confined to quiet oxbows, while the mud turtle (Kinosternon sp.) and musk turtle (Sternotherus depressus) inhabit the stream channels as well as the oxbows. The river turtle (Pseudemys concinna), is often seen in schools in shoal area pools. Spiny softshells (Trionyx spinferus) were once common in pre-pollution days of intensive cotton mono-culture and urban development. Snake are rare in the Piedmont floodplain.

Several reptilian species are unique in the upper Flint region as members of a relic south Georgia fauna, as they are found to exist here outside their reported range. Species which are normally found in the Coastal Plain, but which inhabit the upper Flint River, include the green tree frog, loggerhead musk turtle (Sternotherus minor), brown water snake (Nerodia taxispilota), eastern cottonmouth (Agkistrodon piscivorus), eastern coral snake (Micrurus fulvius), and the clam-eating Barbour's map turtle (Graptemys barbouri) (Wharton, 1978).

The most common birds of Georgia bottomlands are the prothonotary, parula, and magnolia warblers, alder and acadian flycatchers, grey kingbirds, chuck-wills-widow, and the pileated woodpecker. Flocks of robins, waxwings, and blackbirds pass through the area in migration. The black duck and mallard winter in the swamps and the wood duck nests there. The red-shouldered hawk and barred owl are nearly confined to river swamps, the latter feeding heavily on crayfish which emerge at night to feed on the floodplain floor. The beaver ponds scattered along the river provide excellent habitat for wading birds such as the white ibis (Eudocimus albus) and herons. The osprey feeds on fish that are captured in the stream shallows (Wharton, 1978).

The small mammals found in the floodplain are the short-tail shrew (Blarina brevicauda) and the long-nosed shrew (Sorex longirostris) which forage over the often bare forest floor winter and summer, seeking the rich insect and worm fauna. Rodents of the floodplain include the deer mouse (Peromyscus leucopus), the golden mouse (P. nuttali), and the meadow jumping mouse (Zapus hudsonuis). Furbearer species that occur are mink, beaver, raccoon, muskrat, otter, red fox, grey fox, and bobcat (Wharton, 1978).

Beaver dams are a feature of the Flint River basin that have had a tremendous impact on the floodplain ecosystem. Ponds created by the beaver dams often result in death of floodplain timber. Once beavers desert a pond, the area becomes a temporary marsh, in some cases going through serial stages of succession. Usually, however, the beavers return and start over. On the positive side, beaver ponds trap silt and increase diversity of habitat by creating open water, semi-permanent water, marsh and shrub communities, which favor certain species (turtles, ducks, wading birds, pickerel and bowfin), and maintain more diverse food chains. On smaller branches beavers may actually create miniature floodplains by silt-entrapment. These areas are known to be excellent duck hunting areas and many locations along the river are leased for that purpose (Wharton, 1978).

Game species include white tailed deer, squirrel, raccoon, rabbit, opossum, dove, quail, and turkey. In the upper or Piedmont region of the Flint, 1984 deer population estimates range from 15 to 40 deer per square mile (less than one deer per acre). Crawford and Upson counties have the highest populations of 30-40 per square mile (less than one deer per acre). Clayton County, metropolitan in nature, has the lowest deer population supporting approximately 15-20 deer per square mile (less than one deer per acre). The counties of Fayette, Meriwether, Pike and Spalding have between 20-35 deer per square mile (less than one deer per acre). Current annual harvest estimates per square mile range from 10 to 14 deer (less than one deer per acre); Fayette having the highest of 14 and Spalding having the lowest at 10 (Georgia DNR, 1985a, 1985b, 1985c).

Turkey population estimates per county in the upper Flint for 1984 range from highs of more than 350 turkey in Crawford, Meriwether, and Upson Counties to lows of less than 40 turkey in Fayette County. Pike and Spalding Counties have

350 and 250 turkey, respectively. Crawford and Upson Counties have excellent harvest estimates while Fayette has none (Georgia DNR, 1985b, 1985c).

Small game population and harvest information was unavailable for the area. On the Piedmont, 136 licenses were sold in 1984 to individuals for commercial trapping. Species taken include raccoon, bobcat, red and grey fox, otter, mink, muskrat, beaver and opossum (Georgia DNR, 1985b, 1985d).

Coastal Plain floodplains in the Flint River Basin also support a variety of wildlife. Among the amphibia inhabiting the floodplain are the two large, nearly legless forms locally called "conger eels", Amphiuma sp. and Siren sp. These species and the waterdogs (Necturus sp.) seldom, if ever, emerge from the waterways. The Alabama waterdog (Necturus macularis beyeri) may be confined to the ACF system. The redspotted salamander breeds on the floodplain as does the spotted salamander, but are more frequent in the second bottoms and terraces. The southern red salamander, mud salamander (Pseudotriton montanus) and dwarf salamanders (Eurycea quadridigitata) are found in moister situations with the mud salamander probably confined to the floodplain. The marble salamander and mole (Ambystoma talpoideum) are also found, the marble confined to the floodplain as it is in the Piedmont. Although a number of Coastal Plain frogs may visit the floodplain, few are restricted to the river swamps. One is the bird-voiced tree frog (Hyla avivoca), which breeds in the inundated backswamps. On the banks of swamp streams one frequently finds the river frog as far north as Kinchafoonee Creek. Also the bronze frog, bull frog, and carpenter frog (Rana virgatipes) may be floodplain breeders. The narrow-mouth toad, southern toad, cricket frog, and leopard frog are often encountered on the floodplain, although they are not restricted to it. Commonly found are the alligator snapper (Macrochelys temmincki) the largest freshwater turtle, and the mud and musk turtles. The rare spotted turtle (Clemmys guttata) is more often found near the smaller streams and branch swamps. The Barbour's map turtle is also found in the Coastal Plain. In the smaller tributary streams the Florida cooter (Chrysemys floridana) and river cooter (C. concinna) are the dominant forms along with the yellow-bellied turtle (C. scripta scripta), the latter seeming to prefer the quieter parts of the river and sloughs. Other turtles inhabiting the area include the red-eared turtle (C. scripta elegans), the spiny softshell turtle (Trionyx spiniferus) and Florida softshell turtle (T. ferox), and the chicken turtle (Deirochelys reticularia). The green anole and five-line skink range within the floodplain preferring high humidity conditions. Snakes to be found on the Coastal Plain include: Eastern diamondback, the rainbow snake (Farancia erytrogramma), mud snake (Farancia abacurd), brown snake (Storeria dekayi), red-bellied snake (S. occipitomaculata), cottonmouth, copperhead (Agkistrodon contortrix), gray rat snake (Elaphe obsoleta) and pine snake (Pituophis sp.) (Wharton, 1978).

The most abundant breeding birds found on the Flint River Coastal Plain floodplain are red-eyed vireo (Vireo olivaceus), parula warbler, cardinal (Cardinalis cardinalis), and carolina wren (Thryothorus ludovicianus). Other permanent or breeding residents include the yellow-crowned night heron (Nycticorax violaceus), wood duck, red shouldered hawk, chimney swift (Chaetura pelagica), woodcock (Scolopax minor), barred owl, pileated and hairy woodpeckers (Picoides villosus), bluejay (Cyanocitta cristata), chickadee (Parus sp.), tufted titmouse (Parus bicolor), Swainnson's warbler, common grackle (Quiscalus quiscula), and towhee (Pipilo sp.). Additional summer or spring residents found are green-backed heron (Butorides striatus), swallowtail kite (Elanoides forficatus), Mississippi kite (Ichtihia mississippiensis), arcadian flycatcher, veery (Catharus fuscescens),

white-eyed vireo (Vireo griseus), prothonotary and hooded warbler (Wilsonia citrina) (Wharton, 1978; Georgia DNR, 1976).

Small furbearers to be found include mink, muskrat, beaver, skunk, weasel, otter, gray and red fox, and bobcat. Small game includes bobwhite quail, mourning dove, gray squirrel, fox squirrel, cottontail rabbit, raccoon, and oppossum. The best quail lands and populations are found in the plantation counties of Dougherty, Baker, Calhoun, and Mitchell. However, the other counties in the Coastal Plain support good quail population. Rabbit and dove are also found mostly in the above mentioned plantation counties but can be found in all the other Coastal Plain counties as well. Gray and fox squirrel populations are rather stable throughout the entire Coastal Plain region of the Flint River (Wharton, 1978; Georgia DNR, 1976, 1985a).

Recreational big game in the lower Flint River are the white tailed deer and turkey. Estimates for 1984 deer populations range from 460 deer in Seminole County to 12,230 deer in Talbot County. Talbot County has a big deer population due to the existence of the Big Lazar Creek Wildlife Management Area (WMA).

In descending order the highest populations occur in the following counties: Decatur (8,585), Macon (6,800), Taylor (7,990), Worth (4,880) and Baker (4,540). Other counties ranging from 500 to 4,000 deer include Calhoun, Crisp, Dougherty, Dooley, Lee, Mitchell, reflected in the annual deer harvest of the counties, ranging from Talbot with 3,057 deer and Seminole with 115 deer. The counties with highest deer harvest are Decatur (2,146), Taylor (1,998), and Macon (1,718). The other county's deer harvest range from 129 to 1,300 (Georgia DNR, 1985a, 1985b, 1985c).

Talbot County again has the highest turkey population with 2,000-2,500 (attributable to the Big Lazer Creek WMA) and Crisp County the lowest with 10 turkey. Taylor County has the second highest turkey population with 1,000-2,000. The remainder counties range from 40 to 900 turkey. In those counties with 1984 turkey seasons Talbot County had the highest harvest of 150-175 with the others having a general harvest range of 15 to 100 turkeys (GA DNR, 1985a, 1985b, 1985c).

Throughout the Flint and Chattahoochee River basins on the Coastal Plain a total of 282 licenses were sold to individuals for commercial trapping in 1984. The major species trapped were raccoon, bobcat, red and gray fox, otter, mink, coyote, and muskrat (Georgia DNR, 1985a).

STATE/FEDERAL FOREST AND WILDLIFE MANAGEMENT AREAS

Big Lazer Creek Wildlife Management Area

Big Lazer Creek Wildlife Management Area (WMA) was created in 1974 when the State of Georgia initially purchased the land. Total acreage is now 1,470 ha (3639 acres). The WMA is located 65 km (40 mi) northeast of Columbus, Georgia in Talbot County with the Flint River bordering the area at the Upson County line (Georgia DNR, 1980a). Big Lazer Creek WMA is generally an upland area. Gum Creek and Big Lazer Creek flow into the Flint River. The objective of the WMA is to actively manage to enhance wildlife populations and their habitats, and to allow a maximum amount of public use of the area for recreational purposes, as long as wildlife populations and habitats are not adversely affected (Georgia DNR, 1980a).

Within the Gum Creek bottom area exists a mature hardwood forest consisting of oaks, basswood, ash, birch, beech, yellow poplar, sweetgum, and others in excess of 76 cm (30 in) in diameter at breast height (dbh). It is estimated that their replacement would take more than 100 years (Schwarz, 1976; Georgia DNR, 1982).

The wild turkey is the game species receiving primary management importance and the WMA has one of the finest turkey populations and one of the densest white tailed deer populations in the State of Georgia. Small game species present on the WMA include cottontail rabbit, swamp rabbit, gray squirrel, raccoon, opossum, bobcat, gray fox, and red fox. Other fur-bearers include mink, otter, beaver, spotted skunk, and striped skunk. Game bird species present include bobwhite quail, mourning dove, and woodcock. Waterfowl are limited to the Flint River and Big Lazer Creek. Species include wood ducks, mallards, and other species of migratory dabbling ducks. Wood ducks nest in the area but not in significant numbers. The black bear is known to occur on the area sporadically (Georgia DNR, 1980a).

Plants of significant interest occurring on the WMA include ginseng (Panax quinquefolium), and Croomia (Croomia pauciflora), Fringed campion (Silene polypetala), Yellow lady's slipper (Cypripedium calceolus var. pubeseus), red honeysuckle (Rhododendron prunifolium), and Bay-star vine (Schisandra glabra). (Georgia DNR, 1980a).

Primary use of Big Lazer Creek WMA by the general public involves activities associated with hunting of which deer, turkey, and small game are most popular. The WMA provides much needed public hunting land in this part of Georgia since most other suitable hunting land is either leased for hunting or use is heavily restricted. Other forms of public use permitted on the WMA include fishing access to the Flint River and Big Lazer Creek and non-consumptive uses such as sight-seeing, nature observation, hiking, photography, and camping. Approximately 1200 hunter days are spent on the area each year during the various hunting seasons and approximately 200 man-days are spent on the area each year for non-consumptive use (Georgia DNR, 1980a).

Chickasawhatchee Wildlife Management Area

The State of Georgia, Department of Natural Resources leases these lands owned by paper companies for specific use as a Wildlife Management Area. St. Joe Paper Company owns approximately 8808 ha (21,767 acres) and Southwest Forest Industries owns approximately 93 ha (230 acres) with both companies managing intensively for pulpwood production (Georgia DNR, 1980b).

The WMA is approximately 23 km (14 mi) southwest of Albany, in southwestern Georgia and emcompasses parts of Dougherty, Calhoun and Baker Counties. Much of the WMA consists of low lying bottomlands, swamps, and low depressions which are under water or fairly wet during most of the year. Several creeks flow through the area, the primary ones are Chickasawhatchee, Spring, Keel, West Chickasawhatchee, and Kiokee Creeks, all in the Flint River drainage basin (Georgia DNR, 1980b).

White tailed deer are plentiful with deer track census since 1966 indicating densities as high as 43 deer per square mile (less than one per acre). Annual counts of turkey populations are believed to average about 60 birds (one per

366 acres). A significant feral hog population is present, providing a considerable amount of public hunting. Small game species found on the area include cottontail rabbit, swamp rabbit, gray squirrel, fox squirrel, raccoon, opossum, bobcat, and gray fox. Furbearers probably found include mink, otter, beaver, long tail weasel, and spotted and striped skunk. Game birds include the bobwhite quail, mourning dove, wood cock, and Wilson's snipe. The most common waterfowl found are wood duck, mallards and blue-winged teal. Other migratory species are frequently to occasionally found on the WMA during migration. Wood ducks remain in the area the entire year and commonly nest. The limpkin has also been reported in the WMA (Georgia DNR, 1980b).

Federally endangered, threatened, or rare wildlife species known to be present include the American alligator, and the gopher tortoise. Occasional sitings of the bald eagle, golden eagle (<u>Aquila chryseetos</u>), and possibly the cougar (<u>Felis concolor</u>) have occurred. Potential habitat exists for the indigo snake (<u>Drymarchon corais</u>) (Georgia DNR, 1980b).

Deer hunting is the most popular form of public use on the WMA. Approximately 1,750 hunter days were spent by 1,016 hunters in 1979-80. Approximately 601 hunter days were spent on small game hunts by approximately 488 hunters during the same year and 270 hunter days were spent dove hunting (Georgia DNR, 1980b).

Data obtained from deer hunters during 1976-77 and 1979-80 hunts indicate that a significant number of hunters originate from within 161 km (100 mi) of the WMA. A smaller but significant number originate from over 242 km (150 mi). A small amount of non-residents also used the area, Florida and Tennessee supplying the majority. Small game hunters generally originated from within 161 km (100 mi) radius of the Albany area. Non-consumptive use appears to be moderate to low (Georgia DNR, 1980b).

<u>Albany Nursery Wildlife Management Area</u>

The 120 ha (297 acres) Albany Nursery Wildlife Management Area (WMA) is owned by the State of Georgia and is located in northwestern Dougherty County. The primary goal of the WMA is the production of seed crops for use in wildlife management programs for the Game Management Division of the Department of Natural Resources. Secondary goals are to provide recreational hunting of dove and squirrels (Georgia DNR, 1980c).

White tailed deer populations are excellent and wild turkey are mostly as transient small groups or individuals. Small game consisting of gray squirrel and rabbit are plentiful. Game birds found include bobwhite quail and mourning doves. Wood duck are found in abundance and nest in the WMA. Furbearers consist of raccoon, opossum, bobcat, grey fox, red fox, beaver and otter. A variety of songbirds common to the geographic region nest on the WMA. Several species of raptors, including kestrels, red-tailed hawks, marsh hawks and broad winged hawks hunt the area during winter (Georgia DNR, 1980c).

The only Federally endangered or threatened animal found in the WMA is the American alligator which is only occasionally present along Kiokee Creek. No rare, endangered or threatened plants are known to occur (Georgia DNR, 1980c).

Dove hunting was the only hunting allowed until 1980 when squirrel hunting was permitted. Harvest trends for doves from 1975-1979 ranged from 217 to 462 doves harvested. Approximately 90% of the dove hunters were from the local area within 32 km (20 mi). Harvest information on squirrels was unavailable. Non-consumptive uses are mostly educational, either as an outdoor laboratory for science classes, or as a demonstration area for wildlife management techniques (Georgia DNR, 1980c).

Lake Seminole Wildlife Management Area

The Lake Seminole Wildlife Management Area (WMA) is leased by the State of Georgia from the U.S. Army Corps of Engineers. Lake Seminole (Jim Woodruff Reservoir) was formed in 1957 by the construction of a dam at the confluence of the Flint and Chattahoochee Rivers. Located in Seminole and Decatur Counties on lands surrounding Lake Seminole, the total area is 2,000 ha (5,000 acres). The general purpose of the WMA is to provide recreation for hunters, fishermen, photographers, bird watchers and others who may have an interest in the wildlife of this geographic region (Georgia DNR, 1980d).

Deer population estimates in 1980 showed populations were moderate to low, estimated at approximately one deer per 60-70 acres. Turkey populations have been increasing in recent years. Small game present include rabbit and squirrel. Game birds occurring include bobwhite quail, mourning dove, woodcock, and snipe. Wood ducks are present during all seasons of the year and in 1980, 175 nest boxes were used. The WMA and surrounding areas provide good winter habitat for other species of migratory waterfowl such as mallards, ring-necks, scaup (Aythya spp.), widgeon, teal, and gadwalls (Anas strepora) and there is also an established resident flock of Canada geese (Branta canadensis). Furbearers found include bobcat, raccoon, opossum, beaver, fox, otter, and mink. Nesting and wintering habitat for a variety of songbirds is present. A nesting colony of great blue herons and anhingas also exist. In the spring of 1980 four active osprey nests were discovered on Lake Seminole (Georgia DNR, 1980d).

Federally endangered or threatened species in the area are the American alligator, indigo snake, gopher tortoise, and bald eagle. The red-cockaded woodpecker (Picoides borealis) occurs in several locations in Decatur County, and although they have not been observed on the WMA, the possibility of their presence exists (Georgia DNR, 1980d).

No exact hunting data are available, but it was estimated in 1980 that 12 to 15 deer were killed annually. Turkey hunting occurs in Decatur County, but not in Seminole County due primarily to scarcity of turkey habitat. Quail harvest is estimated at 125-150 annually and dove harvest is estimated at 100-150 birds annually. Woodcock and snipe are hunted very little and most are taken coincidentally while quail hunting, harvest estimates in 1980 were less than 40 birds killed. Waterfowl harvested during the hunting seasons are estimated at approximately 500 annually (Georgia DNR, 1980d).

Ninety-five percent of hunters are Georgia residents and 5% non-residents, and 80% of those are from the local area. A significant number of quail and waterfowl hunters originate from the metro-Atlanta area and other portions of north Georgia. Preferred type of hunting and species are (in the order of preferrence): small game-quail, dove, squirrel; big game-deer; and waterfowl-wood duck, mallard and others (Georgia DNR, 1980d).

Lake Seminole - Jim Woodruff Lock and Dam

The U.S. Army Corps of Engineers (COE), Mobile District oversees the Lake Seminole Federal project. Lake Seminole was created in 1957 by the construction of a lock and dam at the confluence of the Flint and Chattahoochee Rivers and at the headwaters of the Apalachicola River, located at the junction of the States of Alabama, Georgia and Florida (U.S. COE, 1980).

The U.S. Corps of Engineers officially oversees all Federal lands in the project area. However, some lands are leased to the states of Florida and Georgia for use as wildlife management areas. The remaining lands under Federal purview are managed in cooperation with the three involved States. The management of the lands under the Corps of Engineers are done passively and is in more of protection than management mode. Rare, unique, endangered and threatened species, and species of special concern receive the most active management. Osprey commonly nest in the Lake Seminole area. The ravines where the Florida Torreya (Torreya taxifolia) grow are protected in the project area (U.S. COE, 1985c).

All lands not within State wildlife management areas are open to public hunting in accordance with existing State and Federal regulations unless devoted to a special use such as camping. Harvest estimates are unavailable but most recreational hunting is for quail and turkey (U.S. COE, 1985c).

Lake Seminole also provides a multitude of recreational uses. Fishing is the predominant activity, with general boating, water skiing, swimming, camping, sightseeing and picnicing also occurring (U.S. COE, 1980).

SPECIAL,UNIQUE OR SENSITIVE ECOLOGICAL AREAS

Limesinks

Limesinks occur in regions underlain by limestone rock or dolomite, and in Georgia are confined to the Limesink Region (Dougherty Plain) and Valdosta Limesink Region. Several limesinks occur in Veteran's Memorial State Park on Lake Blackshear (formerly Flint River floodplain). The sinks occur in many shapes and depths, but are generally round; some are shafts with sheer walls. They are formed by the collapse of the roof of underground caves dissolved out of solid limestone by subsurface streams and seepages. Those with permanent water may accumulate enormous layers of peat. The fauna of the sinks are poorly known, generally Coastal Plain species of the gum-cypress habitat association (Wharton, 1978).

The limesinks, because of their variety and type, are a diverse and valuable resource. Many apparently funnel water to recharge underground aquifers, others collect rainwater and act as reservoirs or ponds. They create the landscape diversity necessary for a spectrum of plant and animal food chains in an otherwise monotonous terrain, largely agricultural, since limestone soils are markedly fertile and usually flat (Wharton, 1978).

Coastal Plain Springs

The Flint River has several springs occurring in the Coastal Plain region. In Dougherty County, Radium Springs is found and in Baker County, Blue Springs, and Lester Springs are found. Radium Springs is the largest spring in the State

with an average flow of 35 mgd and ranges from 2.6 to 87 mgd. Several large springs adjoin Spring Creek in Decatur County, one of these is Brinson Spring (Wharton, 1978).

Large springs are important and distinct hydrologic and geologic features. They are botanically and zoologically valuable in their scarcity and uniqueness. They are usually pure, underground rivers, well mineralized waters supporting a highly productive flora and fauna. They also serve as thermal refuges for fish such as striped bass during hot weather. The spring and the spring run below it and the adjacent forest should be considered together as an ecological unit (Wharton, 1978; U.S. FWS, 1985).

Fall Line

The Piedmont and Coastal Plain Provinces are separated by the Fall Line area. The Fall Line is part of the Piedmont Province in the Pine Mountain District. The sediments in the area are deep, sandy soils creating "sandhills" as opposed to the granites, gneisses and schists of the Piedmont and the marine derived sediments of the Coastal Plain. The Pine and Oak Mountain ridgeline traverses the Fall Line in a northeasterly to southwesterly direction. The mountains average well over 305 m (1,000 feet) in elevation, giving the crest a height of more than 91 m (300 feet) over the valley floor. The Flint River drops almost 15 m (50 feet) as it moves through the area creating a large amount of fall over shoals (Georgia DNR, 1976).

The mountains and sandhills create a corridor of unusual flora and fauna blending the Mountain, Piedmont and Coastal Plain Provinces. The ravines, slopes and bluffs of the Pine Mountains support examples of this mixture. The ravines are cool and moist, with small streams and steep sides. Dripping Rock Falls in Upson County on the Flint River is an example of disjunct northern and southern floral elements together and boasts the largest concentration of plant species anywhere along the river. Trees to be found include beech, black gum, sourwood, sweet bay, and American holly; shrubs occurring are Carolina rhododendron, leucothoe, titi, myrtle, mountain laurel, sweet shrub and green briers. The fauna is also a mixture of southern and northern affinities (Warren, 1974; Wharton, 1978).

Sprewell Bluff, a 61 m (200-foot) high woodland bluff overlooking the river exemplifies the Fall Line Area. The dense forest includes ash, styrax, Georgia blackberry, silverbell, buckeye, fringe tree, and palmetto near its northern limits. The shoals above and below the Bluff contain the best remaining colonies of spider lily (Hymenocallis) (Georgia DNR, 1976).

Flat Shoals and Yellow-Jacket Shoals are other areas of interest. Granite faces along Flat Shoals have wet and dry areas of endemic rock outcrop plants. The wet areas accommodate spiderworts, Xyris, arrowhead lilies, lizard's tail, sedges and ruhes, and rice-cut grass. Dry areas support lichen, annual and perennial herb and/or shrub communities. At Yellow-Jacket Shoals the river steeply slopes creating white-water conditions with class three canoe limitations (Warren, 1974).

The environmental importance of the Fall Line area cannot be overemphasized. The unique blending and combinations of northern and southern plant and animal species affinities are not found elsewhere. The relatively undisturbed river with its thundering rapids and granite outcrops support one of the last remaining habitats for the shoal bass, endemic to the ACF River basin system.

The Flint is the longest section of any Georgia Piedmont stream which is undammed and virtually unaltered by man (Ober, 1977; Georgia DNR, 1971).

The Georgia Natural Areas Council designated this portion of the river as an important scenic area to be preserved in its natural state and rated the Flint River as the number one priority out of 53 rivers for inclusion in the State Scenic Rivers System (Bailey, 1974).

Radford and Martin (1975) recommended almost the entire area where the Flint River flows through Pine Mountain as a natural landmark called "Flint River Water Gap Wilderness Area", and listed it as one of the three most outstanding sites in the Piedmont of eastern America when the following criteria are considered" community and species diversity; endemic, rare and disjunct species; edaphics, topography, and geology.

The Georgia Department of Natural Resources during the Sprewell Bluff Dam controversy proposed the concept of a "Natural River Park" for this portion of the river. The main purpose of the park would have been for water-oriented recreation and environmental preservation (Bailey, 1974).

WATER PROJECTS AND OTHER PROPOSALS

Water projects are considered for a variety of purposes, the primary ones being: navigation, water supply, flood control, hydroelectric power, fish and wildlife resources and recreation. They are funded and constructed at the private, county, State, or Federal level, and many times in combination.

In 1963, Congress authorized three U.S. Corps of Engineers reservoirs, Spewrell Bluff, Lazer Creek, and Lower Auchumpkee Creek, on the Flint River near Thomaston. Primary purposes of the projects included flood control, flow regulation for power generation, downstream navigation, recreation, and fish and wildlife (U.S. FWS, 1960; U.S. COE, 1967, 1968, 1969a, 1969b, 1987).

The three dam and reservoir sites were in an area that is unique environmentally as well as being aesthetic. Occurring at the Fall Line, it is an ecotone of flora and fauna found in both Piedmont and Coastal Plain areas. Further, the Flint River is the last major river in Georgia to have an undeveloped Fall Line. These areas also support one of the last remaining habitats for the shoal bass, endemic to the ACF system. Other sport fishery resources consist of the largemouth bass, various sunfishes, and the channel and flathead catfish (U.S. FWS, 1960; Georgia Conservancy, 1974).

The project area as well as downstream floodplain habitats, contain high quality bottomland hardwoods. Game species include deer, turkey, squirrel, raccoon, rabbit, opossum, dove, quail and wood duck. Numerous species of waterfowl utilize the river and tributary areas during spring and fall migrations. Other furbearer species include mink, beaver, muskrat, otter, fox and bobcat (U.S. FWS, 1960).

Non-game species of importance include red-cockaded woodpecker, bluestriped shiner, Barbour's map turtle, and various mollusk species including the Georgia lamp pearly mussel. Non-game related activities are composed of bird-watching, rafting, canoeing, camping, hiking, picnicing as well as scientific study (U.S. FWS, 1960).

The major impact from the projects would consist of the inundation of the main river channel and tributary streams; conversion of a lentic (running) to a lotic (standing) water habitat; and flooding of adjacent bottomland habitat. Associated land-clearing activities would have also reduced available terrestrial habitat. Other adverse impacts to fish and wildlife downstream could have occurred depending on the quantity and quality of water releases from the reservoir (U.S. FWS, 1960).

The Spewrell Bluff project proposal had been a controversial issue. The State of Georgia withdrew support of the project in October 1973, calling for implementation of the proposed Georgia Department of Natural Resources "Natural River Park" for the area (U.S. FWS, 1960). Since the other two projects were contingent on the Spewrell Bluff project, planning for them was never begun. The passage of the Omnibus Water Resources Development Act of 1986 deauthorized these three Flint River projects (U.S. FWS, 1984, 1987; U.S. COE, 1987).

Currently the State of Georgia is constructing a reservoir on Gum Creek, a tributary to the Flint River in Talbot County, on the Big Lazer Creek State Wildlife Management Area. The primary purpose of the project is to provide fishery habitat. Areas to be inundated by the reservoir include bottomland hardwood habitat. Construction of the project will also eliminate/alter upland habitat currently used by terrestrial game and non-game species. The project will probably be completed in 1987 (Johnson, 1982; Georgia DNR, 1982).

The U.S. Army Corps of Engineers, Savannah District is currently conducting the South Metropolitan Region Water Resources Management Study for a six county area adjacent to south Atlanta. The study was authorized by a resolution adopted by the U.S. House of Representatives Committee on Public Works and Transportation on November 14, 1979. The study is to address the following water resource problems and needs: 1) regional water supply, 2) flood damage reduction, 3) water-quality management 4) fish and wildlife conservation, 5) management of floodplain lands, 6) water-related recreation, and 7) protection of stream environments. In addition, development of alternatives to meet the above needs will also assess secondary benefits which might result, such as recreation and improved stream flows (U.S. COE, 1985a, 1985b, 1987).

The counties in the south Atlanta water supply study include, but are not limited to Coweta, Fayette, Henry, Spalding, Meriwether and Pike. The area water supply and quality is being affected by the rapid development of the Atlanta area. Municipal and industrial water supply is currently available from surface water, ground water and spring sources in the area. The upper Flint River basin is one of the major water supply sources in the study area (U.S. COE, 1985a, 1985b, 1987).

The study was initiated in Fiscal Year 1984. A reconnaissance level investigation of water resources problems and needs was conducted and a Reconnaissance Report was completed in January 1985. A summary of problems and needs from the Reconnaissance Report indicated that adequate water supply and flood damage reduction appeared to be the most prevalent water related needs in the study area; and that surface water supply sources should be protected from potential water quality degradation (U.S. COE 1985a, 1985b, 1987).

The feasibility phase of the study was begun in Fiscal Year 1986. Proposed solutions indicated in the early Feasibility Phase include expansion of existing water supply facilities. Developing water supply systems within the area or "buying" from the

Atlanta area. Most of the water supply proposals for the Flint River and tributaries consist of new construction of dam and reservoirs. Some of the proposed water supply solutions could greatly affect fish and wildlife resources and their associated habitats. It will be necessary to closely evaluate the terrestrial and aquatic changes that will result from the possible new construction. Although the headwaters of the Flint River have been adversely impacted by activities occurring in the Atlanta area, its upper basin is relatively undeveloped. The upper Flint basin has extremely high fishing pressure. Alteration or elimination of the stream fishery will mark a change in fishery types as well as utilization. The upper basin supports good wildlife populations, game and non-game. Alteration of upland forests and elimination of bottomland forests would reduce available habitat for use by wildlife species, which is already at a premium in areas adjacent to the Atlanta area. Although the proposed potential water supply solutions are above the Fall Line and out of the environmentally sensitive areas such as Spewrell Bluff, they could impact the Fall Line habitats depending on the quality and quantity of releases to the downstream area (U.S. FWS, 1984, 1987b).

In conclusion, the upper Flint River system does have a water supply problem, and the problem will continue to increase in the areas adjacent to Atlanta. However, there are alternatives, that could provide the solution to the water supply problems but they must be compatible with existing fish and wildlife resources and their associated habitats (U.S. FWS, 1984, 1987b).

LAND AND WATER USE TRENDS

Overall the Flint River basin is experiencing a slight increase in land and water use. The activity is concentrated in the South Atlanta area, and other major population centers such as Albany and Bainbridge, Georgia as well as agricultural areas in southwest Georgia (U.S. COE, 1985a).

Lands adjacent and south of the City of Atlanta are undergoing very rapid residential and industrial development. Development of this type results in extensive land clearing and adjacent habitat alterations. Because ground water is scarce above the Fall Line, water supply in the area for domestic as well as industrial uses is at a premium. However, new information from U.S. Geological Survey studies indicate that ground water resources have potential as a limited water source above the Fall Line. Water quality and distribution is another major water demand issue. The substantial water quality problems existing at the Flint River headwaters have been reduced by the Atlanta Three Rivers Project completed in 1985. The project removed the Flint River Plant wastewater treatment discharges from the river. In addition, the U.S. COE, Savannah District is conducting the South Metropolitan Atlanta Region Water Resources Management Study to investigate water supply problems and needs in the six-county area of Henry, Fayette, Coweta, Spalding, Pike and Meriwether Counties, adjacent to the Atlanta area (U.S. COE, 1985a, 1985b).

Although some of the major population centers south of the Fall Line have increasing water uses, water supply is not as severe a problem because of abundant ground water resources. However, increase and expansion of agricultural activities in southwestern Georgia has resulted in ground water pumping for irrigation to have increased 200% between 1977 and 1981. A Georgia Geological Survey and U.S. Geological Survey mathematical model to simulate future irrigation use shows aquifer discharge to streams will be reduced by 30% if withdrawals for irrigation continue to increase. This

would substantially affect the base flow of the Flint River in southwest Georgia (Radtke et al., 1980).

Communities in the upper Flint River basin have already recognized the need for increased future water supply and have begun planning for that need. However, they and agricultural interests in southwest Georgia will need to address and realize the limitations of the water supply resources for human use as well as fish and wildlife resources.

APALACHICOLA RIVER BASIN

OVERVIEW

The Apalachicola River originates at the junction of the Flint and Chattahoochee Rivers just north of the Florida-Georgia State line (Figure 5). The Apalachicola River drains an area of about 2,600 sq km (1,030 sq mi). Its main tributary, the Chipola River has a watershed of equal size (Livingston, 1984c). The only dam on the river, Jim Woodruff Dam, located at its headwaters impounds 15,175 ha (37,500 acres) creating Lake Seminole. The Chipola River joins the Apalachicola River 45 km (28 miles) above its mouth (Clewell, 1977).

The Apalachicola River has an elevation along its banks of up to 90 meters (300 feet) above sea level. The area along the river is about 70% woodland with about 40% being classified hardwood, hammocks and titi swamp (U.S. COE, 1978).

The Apalachicola River lies entirely within the lower Coastal Plain Province and is the only river in Florida to stretch from the Piedmont to the Gulf of Mexico. The Apalachicola basin is renowned for its unique biota which results from its continuity with the southern Appalachians and its diversity of physical environments (Livingston, 1984c; Leitman, 1984).

The river flows through two geological regions of the Coastal Plain Province. Above S.R. 20 is the Northern Highlands and below is the Gulf Coastal Lowlands. The upper east side of the river is characterized by steep bluffs and a narrow floodplain (Clewell, 1977).

The bluffs are commonly 30 to 60 meters (100 to 200 feet) above the river surface. Some of the bluffs such as Aspalaga and Alum Bluff drop directly to the river's edge. Much of this area is dissected by steep ravines, many of which begin abruptly at spring steepheads. Many springs occur in and on both sides of the river along the Northern Highlands Province (Clewell, 1977).

The western side of the river within this province is a broad lowland rising gradually from the floodplain to the Grand Ridge region then dropping slightly into the Marianna Lowlands. The Chipola River drains most of the Marianna Lowlands and enters the Apalachicola River about 24.1 km (15 miles) below the town of Wewahitchka. Natural levees of the Apalachicola River near the Chipola cutoff dammed the Chipola River in historical times to form Dead Lakes. A man made dam was built in 1962 to stabilize water levels in Dead Lakes (Clewell, 1977). Below S.R. 20 the bluffs disappear with the exception of Estiffanulga, 15 km (9 mi) below the City of Bristol. In the Gulf Coastal Lowland's Province the river meanders more and the floodplain becomes wider (Clewell, 1977).

HISTORICAL/PRESENT UPLAND HABITATS

The Apalachee Indians began alteration of the upland forests nearly 1,000 years ago with their substantial agricultural practices. In the early 1800's white men found the remaining forests to be pine-oak communities consisting of longleaf pine, black oak, laurel oak, spanish oak, post oak, white oak (*Quercus alba*) and mockernut hickory; other minor species included magnolia and beech (Williams, 1837). Settlers continued the habitat alteration with cotton farming, crop production, cattle and hog grazing, as well as turpentine production and logging. Timber was being cut as early as 1830 along the Apalachicola River and by 1930 virtually all tracts of virgin timber were cut in the Florida panhandle (Clewell, 1986).

Present day forests have been reforested with second growth pines. The upper basin forests east of the bluffs still contain pine-oak communities of longleaf pine, scrub oaks (mainly turkey oak (*Q. laevis*)), with a turf of wiregrass and various herbs and low woody plants. The bluffs contain a rich, mesic forest of southern magnolia, beech, white oak, southern sugar maple, and American holly. The upper portions of the bluffs contain a drier forest vegetated with southern red oak, shortleaf pine, mockernut hickory, post oak, and dogwood. The Marianna Lowlands and Grand Ridge regions contain both longleaf pine woods and mesic hammocks similar to those on the bluffs. The Gulf Coastal Lowlands are typified by flatwoods of longleaf pine, saw palmetto, wiregrass, runner oak, and gallberry. These woods are interrupted frequently by poorly drained depressions and stringers of pond cypress (*Taxodium distichum* var. *nutans*), black gum, sweetbay and titi (*Cliftonia monophylla*) (Clewell, 1977).

The majority of lands adjacent to the Apalachicola River are in private ownership for silviculture purposes except in the lower river which is mostly in public ownership (State of Florida).

URBAN AREAS

The Apalachicola River basin is only sparsely settled. Only four bridges cross the river and four communities are located near its banks. The town of Chattahoochee is located on U.S. Highway 90 at River Mile (RM) 106. The Cities Bristol and Blountstown are located on S.R. 20 near RM 79, and the City of Apalachicola is located at the river mouth on U.S. Highway 98. The Interstate 10 bridge is at RM 100. The communities are small all with populations less than 5,000. The counties all have less than 100 people per square mile (Jackson-45, Gadsden-88, Calhoun-17, Liberty-5, Gulf-21, Franklin-16) (Univ. of FL, 1987).

The communities are based on agricultural production (food crops and silviculture), except for the City of Apalachicola which is based on commercial fishing for and processing of oysters, shrimp and finfish such as mullet and seatrout (Smith, 1985; Livingston, 1984c).

Communities built along the river have had relatively little adverse impact on the system. Some minor direct development has occurred on the banks such as the barge unloading facility near the town of Sneads and seafood industry facilities at the City of Apalachicola. The most substantial problems which exist are the discharges from the sewage treatment plants (STP) for the municipalities of Chattahoochee, Marianna, and Apalachicola and discharge from the Gulf Power Electric Plant at Sneads.

AGRICULTURE

The Marianna Lowlands and Grand Ridge areas have been largely developed for agriculture and pine forests siliviculture. Much of the area adjacent to the Apalachicola River bluffs have been converted to pine plantations. Some bluff environments are being protected at Torreya State Park and at the Marianna Caverns State Park on the Chipola River the unique flora of the Marianna Lowlands is being protected (Clewell, 1977).

The Gulf Coastal Lowlands have experienced substantial modification due to intensive forestry, soybean production, grazing, and drainage. The lowlands east of the river are given some protection within Ft. Gadsden State Park and the Apalachicola National Forest, although intensive forestry is practiced in the Forest. Further, Tate's Hell Swamp has been permanently converted from its natural state by intensive forestry (Clewell, 1977).

WATER QUALITY

In general, the water quality in the Apalachicola River system is good relative to other major river systems in the region. The entire river has been designated as "Outstanding Florida Water" (OFW). Designation of OFW means that the ambient water quality conditions of the river become standards for which all future water quality-related activities will be judged. The purpose of the designation is to allow no degradation of existing conditions.

The State of Forida classifies its surface waters by their designated use. Five water quality classes have been designed with criteria to maintain the minimum conditions necessary to assure the suitability of water for its designated use. Each of these classes have specific water quality standards for parameters such as bacterial levels, metals, pesticides, and herbicides, dissolved oxygen, etc., designed to protect and maintain the use of the water body. The degree of protection is variable with Class I waters having the most stringent standards and Class V waters the least (FL DER, 1985)[1].

There is only one Class I water located within the entire Apalachicola River drainage basin. Mosquito Creek in northwestern Gadsden County is used by the City of Chattahoochee as a drinking water source and therefore is classified as a Class I water from U.S. Highway 90 north to the State line. Class I waters, are those used as potable water supplies, and are afforded the most protection of any waters in the State (FL DER, 1985).

All others waters in the Apalachicola River basin are Class III waters. This includes the Apalachicola and Chipola Rivers, Dead Lake, Lake Wimico, Lake Seminole, and all other creeks, ponds, or surface waters. Class III water standards are intended to protect recreation and the propagation and maintenance of a healthy well-balanced population of fish and wildlife (FL DER, 1985).

There are several types of pollution sources which affect water quality in the Apalachicola River, consisting of sources from upstream (i.e., Georgia, Alabama and Florida), point source discharges into the river and its tributaries, non-point sources, airborne sources, and barge traffic (FL DER, 1984).

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1 See Appendix II for State of Florida Surface Water Quality Criteria.

Florida Department of Environmental Regulation (FL DER) has the responsibility for permitting point sources. Non-point sources have not been regulated to any extent in the basin. Although urbanized areas of the basin are small, runoff from the relatively steep terrain from cities in the upper river could become a problem in the future. Other sources of non-point runoff in the basin include forestry, agriculture, and road construction and operation (FL DER, 1984).

Some water quality problems have been documented in the tributaries of the Apalachicola River. Florida State Hospital in Chattahoochee, which discharges into a tributary of Mosquito Creek, has had problems with high phosphorus levels in its effluent indicated by fecal coliform levels (Douherty, 1980; Nicol, 1979). Another Apalachicola River tributary, Sutton Creek, has experienced levels of dissolved oxygen in violation of State standards (Kobylinski, 1981). This violation is due to the Blountstown sewage treatment plant. The only other major point source discharge is the Gulf Power Scholz Electric Power Plant near Sneads. Violations of National Pollution Discharge Elimination System (NPDES) discharge limits were noted in 1982, and an illegal sanitary waste discharge was found in 1983 (FL DER, 1984).

The Environmental Protection Agency's (EPA) STORET data base for the Apalachicola and Chipola River basin with a combined period of record from 1924 to the present, reports parameters of temperature, dissolved oxygen, pH, bacteria, nutrients, turbidity, solids, organic toxins, and inorganic toxins. The data show the water quality in the basin to be good with the exception of the areas near the municipalities of Chattahoochee, Marianna, and Apalachicola. Water quality in these areas reflected poor treatment of wastewater discharges and urban runoff with dissolved oxygen, bacteria, and nutrient violations (Leitman, 1984).

Although the Apalachicola River is considered a "pristine" river system, past and current land-use practices have impacted the water quality of the river. Limited contamination information is available; however, in a 1965 chlorinated hydrocarbon pesticide survey of United States river basins, dieldrin was the only contaminant detected in the river. In addition, as part of a 1969-1977 National Pesticide Monitoring Program (NPMP), fish samples from the river had organic contaminant residue levels that were moderately high in comparison with those of other southeastern and Gulf coastal rivers. Following the national trend from 1969 to 1977, total DDT and dieldrin decreased; PCBs increased, and toxaphene, not found in 1971, increased dramatically in 1974 in the river. Lead and cadmium were available in trace amounts and arsenic and selenium residues were found to decrease from 1972 to 1973 (Winger, 1981).

The U.S. Fish and Wildlife Service (FWS) in 1978 collected aquatic and aquatic-dependent biota from the Apalachicola River for analysis of selected organochlorine pesticides, PCBs and metals. Comparing the 1978 residue levels in fish with that from the NPMP stations, organic contaminant residues in biota from the river were considered moderately high. In comparison with the 1974 NPMP southeastern and Gulf coastal levels, residue concentrations of DDT, PCB, and toxaphene, particularly from the upper stations on the Apalachicola River generally exceeded the median concentration for all fish. Mean residue concentrations of total DDT, PCB and toxaphene also exceeded the 1979 national geometric mean. In 1978 the organic contaminant levels in the biota were also found to be more concentrated in the upper than in the lower reaches of the river. The elevated levels of organic contaminant residues in the biota from the upper river may reflect the intensive agricultural and industrial development

on the tributary streams (Chattahoochee and Flint Rivers). Lake Seminole apparently serves as a settling basin for most of the contaminants, however, the passage of some material through the lake may account for the somewhat elevated levels of these contaminants in the upper river over those in the lower reaches. Total DDT, total PCB, and toxaphene were the contaminants with highest concentrations in the biota, but all were below 2 ug/g and did not exceed U.S. Food and Drug Administration (FDA) action levels. However, organic residues in the biota, particularly from the upper river exceeded National Academy of Science-National Academy of Engineering (NAS-NAE) recommended residue levels for the protection of aquatic life (Winger, 1981).

In the same FWS 1978 study, metal residue levels exceeding those considered potentially harmful to aquatic biota included: cadmium and lead in mayflies, mercury in herons, arsenic in threadfin shad and Asiatic clam, selenium in largemouth bass and channel catfish eggs, mayflies and Asiatic clams. Metal residues in the biota from the river were generally higher in the lower river than the upper river (Winger, 1981).

Considering the high persistence of the metals and organochlorine compounds, their high potential for bioconcentration and bioaccumulation, and the moderate concentration of residues in the biota of the Apalachicola River, it was concluded by FWS that this system was mildly contaminated in 1978. Increased contaminant loading from future developments in the Apalachicola River watershed could pose a serious threat to the environmental quality of a system which is already showing signs of being stressed (Winger, 1981).

The U.S. Geological Survey in 1979-80 as part of the Apalachicola River Quality Assessment Study conducted a survey of trace elements and synthetic organic compounds and concentrations in bottom sediments and clam (Corbicula sp.) tissues. Concentrations found in the fine-grained sediments and clams were generally at least ten times lower than maximum limits considered safe for biota of aquatic systems. It was also noted that the Apalachicola River basin is affected by non-point source discharges from its upstream tributaries, the Flint and Chattahoochee Rivers. Comparison of trace substances (organic substances) in the river with data from Lake Seminole (upstream) and Apalachicola Bay (downstream) showed lower concentrations in riverine clams. U.S. Geological Survey concluded that the Apalachicola River appeared to not have been heavily affected by trace-substance accumulation in bottom materials (Elder, 1984).

Further, studies conducted by the Office of Coastal Management, Florida Department of Environmental Regulation have indicated that the relatively high metal concentrations are natural and due primarily to the large amounts of alumino-silicate clays found in the the system (Lewis, 1987).

The Chipola River has been the site of trace metal pollution due to battery salvaging activities in the 1970's -1980's. The main source of the salvaging activities occurred at the Sapp Battery plant located north of the town of Alford, Jackson County, Florida. The now defunct plant was located in and surrounded by a cypress-dominated wetland (Steele City Bay swamp) that connects to the Chipola River via Little Dry Creek and Dry Creek. The Environmental Protection Agency (EPA) conducted initial sampling and emergency remedial action of the site. EPA's remedial action basically consisted of liming the "hot spots" to buffer the low pH levels created by the battery acid discharges (Watts, 1984).

In 1983, the Florida Department of Environmental Regulation (FL DER) sampled various areas of possible contamination from the Sapp Battery plant. Results of the sampling effort indicated that at the plant site (Steele City Bay swamp) high levels of lead and sulfate persisted, with somewhat lower levels for cadmium and nickel. There was also evidence that the battery acid was seeping into the Floridan aquifer, the source of water for human consumption in the immediate area. Although early samples showed Little Dry Creek having elevated heavy metal levels, the 1983 sampling effort showed an improvement in the surface water levels (Watts, 1984; Banks, 1984).

In addition to the Sapp Battery plant, another battery salvaging operation, United Metals, Inc. currently operates approximately 3.0 km (1.86 mi) from the Chipola River (also upstream from Dry Creek) in Jackson County, Florida. Although no direct surface connection exists (i.e., stream or creek), contaminated material from the site enters the Chipola River by way of ground water or surface runoff from the unlined holding ponds. In response to both battery plant operations and the concern for fish and wildlife resources, the FWS in 1982 conducted a sampling program from the headwaters of the Chipola River to its confluence with the Apalachicola River. Fish, clams, and sediment samples were analyzed for trace elements of arsenic, cadmium, chromium, copper, mercury, lead, selenium, zinc and organochlorine insecticides (Winger, 1985).

Metal concentrations in the sediment and biota of the Chipola River were not considered excessively high, but the trend was for the levels to generally increase downstream from the plant sites. The increase in the concentration downstream of arsenic, cadmium, chromium, lead and zinc was particularly noticeable in the clam and sediment samples. Such elevated levels may reflect residual contamination from the abandoned battery salvage operations, as well as increased land-use developments (agriculture and urbanization) and/or proximity to highways. Copper concentrations varied considerably, this variability may be attributed to the use of copper-based herbicides in the control of aquatic vegetation in the Chipola River (Winger, 1985).

The study also found organochlorine and PCB residues were low throughout the Chipola River. Somewhat elevated concentrations were found just upstream from Dry Creek though they appeared to be related to more intensive agricultural land-use activities. Although contamination from the abandoned battery salvage plants may have contributed toxic trace metals to the Chipola River the analysis did not reflect serious contamination (Winger, 1985).

Since Dead Lakes is an area of relatively high sedimentation, the Northwest Florida Water Management District (NWFWMD) and the Florida Department of Environmental Regulation (FL DER) conducted field sampling in April - June, 1984 to determine the concentrations of selected metals (lead, cadmium, mercury, nickel, zinc, arsenic and copper). Results of the sampling program showed sediments in Dead Lakes had elevated values for lead, zinc, cadmium, and mercury. For all these metals, their concentrations were either slight or moderate, and not at all comparable to acute pollution cases. The concentrations found in Dead Lakes for zinc and lead were not noticeably different from those found in other unpolluted areas (Banks, 1984).

The FWS during their 1982 field sampling on the Chipola River reached the same conclusion that Dead Lakes may be a sink for contaminants passing through the Chipola River system. Concentrations of most metals in sediment samples were

higher in the lower Dead Lakes than at the mouth of the river. The only organochlorine pesticides found in the river system were located in the lake (Winger, 1985).

Some comparisons can be shown between the Apalachicola and Chipola Rivers. Organic residues found in the Chipola River in 1982 were lower than those reported for biota from the Apalachicola River in 1978. For the same sample period, concentrations of arsenic, cadmium, and selenium in fish from the Chipola River were similar to those measured in the Apalachicola River. However, lead levels in clams from the Chipola River were higher than reported from the Apalachicola River (Winger, 1985).

STREAMS AND FLOODPLAINS

The Apalachicola River is the largest river on the entire Gulf coast of Florida and in terms of flow, (5,000 to 290,000 cfs) is Florida's largest river. The river discharge alone accounts for 35% of the total fresh water runoff for the western coast of Florida. It is approximately 171 km (108 miles) long, with a fairly uniform slope of 0.15 m/km (0.5 ft/mi); it falls approximately 12 meters in its course from Lake Seminole to the Gulf of Mexico. Gulf tides at the river's mouth have a mean range of 0.48 meters (1.6 feet) and affect the river mouth for about 40.4 km (25 miles) upstream (Ager, 1983; Heath, 1971; Livingston & Joyce, 1977).

Physiographically, the Apalachicola River is divided into three segments. The upper river, from Jim Woodruff Lock and Dam (JWLD) downstream to navigation mile (NM) 78.0, passes through an area of steep bluffs on the east and rolling hills on the west. The river is characterized by long, straight stretches and wide bends. The middle river, from Blountstown to Wewahitchka (NM 35.0), meanders through an area of gentle slopes and lowlands. River bends are numerous and acute. The lower river courses through lowlands with a wide floodplain before emptying into Apalachicola Bay as a tidal river. Here the Chipola River and the Brothers River enter the river. Long, straight reaches with a few bends are characteristic as are numerous distributaries (Clewell, 1977).

The river is known as primarily a "sand bed" stream with bottom sediments consisting mostly of medium- to coarse-grained sands and a small percentage of gravel (Leitman, 1984; Isphording, 1985; U.S. COE, 1959 and 1974 river bottom sampling).

The forested floodplain of the Apalachicola River is the largest in Florida. It is 114 km (70.8 miles) long and covers approximately 450 km^2 (173.7 sq mi). The floodplain is 1 km (0.6 miles) wide just below Lake Seminole and broadens to 8 km (4.97 miles) near the river mouth. Of the 211 different species of trees growing in the north Florida area, about 60 are found on the Apalachicola River floodplain (Leitman, 1983).

The major land use in the floodplain is forestry. Most areas were first cut between 1870 and 1925 and have been logged once or twice since that time. Regrowth has been rapid, and much of the floodplain has the general appearance of a mature forest (Clewell, 1977). Most of the floodplain is owned by lumber and paper companies and is managed for timber harvesting. Other extensive uses are beekeeping for honey production, commercial and sport fishing and hunting. Populations and development in the floodplain are relatively sparse. The upper river floodplains and uplands have been largely developed for agriculture and pine

forest silviculture. Much of the area adjacent to the Apalachicola River bluffs has been converted to pine plantations. The lower river floodplains and uplands have experienced substantial modification due to intensive forestry, soybean production, grazing, and drainage. The lowlands east of the river are better protected within the Apalachicola National Forest, although intensive forestry is practiced there. Further, Tate's Hell Swamp has been permanently converted from its natural state by intensive forestry (Clewell, 1977). A large part of the floodplain adjacent to the lower river is publicly owned through the State of Florida Conservation and Recreation Lands (CARL) (formerly EEL) Program, Save Our Rivers Programs, and National Estuarine Research Reserve Program (Miley, 1985).

Information and study of Apalachicola River floodplain soils are few. At two locations near Blountstown and Wewahitchka, floodplain soils were found to be predominantly clay with some silty clay and minor clay loam. Sands on point bars were predominantly fine to very fine and were of the micaceous type whereas most Florida sands are siliceous. Cation exchange capacity and organic carbon content were higher that most Florida soils except peats and mucks. The soil pH was acid but not as acid as most Florida soils (Leitman, 1983).

Each winter and spring the rising waters of the Apalachicola River flood the adjacent wetlands for three to five months. In order of abundance, tree species occurring in the floodplain are water tupelo (<u>Nyssa aquatica</u>), Ogeechee tupelo (<u>N. ogeche</u>), bald cypress, Carolina ash, and swamp tupelo (<u>N. sylvatica</u> var <u>biflora</u>). Other very common species include sweetgum, overcup oak, planer tree (<u>Planera aquatica</u>), green ash, and diamond leaf oak. Swamp tupelo are found only in a few areas along the lower river; Ogeechee tupelo is relatively uncommon in the upper river; sweetbay, cabbage palmetto (<u>Sabal palmetto</u>), and pumpkin ash (<u>Fraxinus profunda</u>) are found exclusively in the lower river; and sugarberry, possum haw and American hornbeam are rare or absent in the lower river; sweetgum is found most commonly on the higher flats and terraces of the upper and middle river, but occasionally found in permanently saturated soils of the lower river.

The upper river has the greatest variety of species, probably because of the greater range in elevations and hydrologic fluctuations (Leitman, 1983).

Leitman (1983) identified five forest types (associations) from the Apalachicola River floodplain:

- Type A - sweetgum/sugarberry/water oak,
- Type B - water hickory/green ash/overcup oak/diamond leaf oak,
- Type C - water tupelo/Ogeechee tupelo/bald cypress,
- Type D - water tupelo/swamp tupelo, and
- Type E - water tupelo/bald cypress.

The type E forest is the most dominate association found. The forest type A is found predominately in the lower river in small amounts. Forest type B is absent from the lower river and forest types C and D are found only in the lower river. Depth of water, duration of inundation and saturation, and water level fluctuation, but not water velocity have been highly correlated with the five forest types. Forest types C, D, and E were generally found at sites having permanent soil saturation with inundation by flood waters 50 to 90% of the time. Forest types A and B were found at locations that were saturated or inundated 5 to 25 percent of the time.

An enormous nutrient source is present in the Apalachicola River floodplain. The dense bottomland hardwood forest contains more than 1,500 trees per hectare (3,700 trees/acre). This vegetation produces some 800 g/m^2 (7,100 lbs/acre) of litter fall annually, which places it among the most productive of forests in warm temperate regions. Much of the litter material is subject to rapid decomposition to both soluble and small-detrital nutrient residues. This production, decomposition, and transport of leaf litter byproducts in the Apalachicola River basin are considered representative of undisturbed bottomland hardwood ecosystems. The annual spring and winter flooding causes appreciable surges in nutrient transport. On an areal basis, the Apalachicola River basin exports greater annual quantities of carbon (13 g/m^2 or 116 lbs/acre) and phosphorus (0.08 g/m^2 or 0.71 lbs/acre) than most watersheds (Mattraw, 1984).

The Apalachicola River water budget is such that the floodplain role in nutrient transport is critical. The Apalachicola River water budget is heavily dominated by streamflow; all inputs and losses within the basin are small relative to the flow in the main channels. In the absence of major pollution sources, nutrient inputs associated with precipitation, ground water, and overland runoff are unlikely to appreciably augment the huge nutrient pool in the river water. The floodplain, with its substantial nutrient production and its direct, prolonged interaction with the flowing river water, is therefore the only factor in the basin that is likely to have considerable influence on the nutrient and detritus yield of the river. It is not accurate to infer from this analysis that precipitation, groundwater flow, evapotranspiration, and other means of water and nutrient exchange in the Apalachicola River basin are unimportant. They are minor only when compared with the total pool associated with streamflow. Rainfall and evapotranspiration rates in warm temperate zones are higher than in most areas of the country, but they nevertheless have relatively little effect on overall streamflow (Mattraw, 1984).

Mattraw (1981) noted nearly all nutrients entering the Apalachicola River streamflow by intrabasin pathways, such as ground water and surface runoff, are natural in origin. Anthropogenic sources are minor, owing to the relatively undisturbed character of the basin. Wastewater effluents consist primarily of a few treatment plants serving small municipalities.

Industry and agriculture are more prevelant in the basins of the two headwater rivers, the Chattahoochee and the Flint. Agriculture in southwest Georgia does not produce high concentrations of chemical constituents in stream water, even during periods of storm runoff. This is attributed to the permeability of the soil, which permits extensive percolation and absorption of materials from the water deposited on agricultural lands. In the upper Chattahoochee River basin nonpoint sources of nutrient loads contribute more nutrients to streamflow than point sources (Mattraw, 1984).

Compared with the entire Apalachicola-Chattahoochee-Flint River basin, the Apalachicola River floodplain is extremely high in carbon and phosphorus yield per unit area. Carbon and phosphorus areal yields from the floodplain are more than 15 times greater than from the basin as a whole. The Apalachicola and Chipola River basins exhibit more areal nutrient yield than the Chattahoochee-Flint basin.

The nutrient yields of the Chattahoochee-Flint watersheds are apparently affected by nutrient retention in the 16 reservoirs of the system (Mattraw, 1984).

Over the long term, the system is dependent on annual spring floods and a healthy, productive, bottomland hardwood forest in the floodplain to maintain nutrient and detritus flow to the bay. In the absence of major alterations to the system, the floods and floodplain forest will continue to be present each year and the annual nutrient-flow pattern should continue (Mattraw, 1984).

The marshes along the Apalachicola River begin at about the confluence of the Brothers River at river mile 12.0 and, although not continuous, occur to the Gulf coast. The upper marshes are predominantly freshwater, consisting of sawgrass, cut grass (Zizaniopsis miliacea), cattails (Typha spp.), bullrushes (Scirpus spp.) and other rushes. Closer to the bay and coast, cordgrass (Spartina spp.) and needlerush (Juncus spp.) become conspicuous (Clewell, 1977).

Impacts to the freshwater marshes have been small, mostly as a result of private individual activities. Minor filling for housing development or dredging for river access have been the dominant activities affecting the marshes. The one exception to this was in the early 1970's, a 13,352 ha (33,000 acre) cattle ranch (now MK Ranch) was established in the Apalachicola River floodplain about 9-10 km (6 miles) above the bay within which extensive sawgrass marshes occurred (Livingston, 1984). Much of the area was illegally cleared, ditched and drained, while waste water was pumped over the dikes into the river system. With EPA as the main force, Federal and State authorities stopped the majority of the unauthorized dredging and filling activities and a court order has been issued for restoration activities. The State of Florida has purchased some of these lands under their EEL program (U.S. FWS, 1985).

The Apalachicola River ravines are drainages that form a unique habitat associated with the Apalachicola River basin. These ravines include small-order stream bottoms and steep valley slopes; the vegetation grades upward from hydric plant communities near the bottom to xeric vegetation at the top of small divides between ravines. The ravines contain a rich, mesic forest with many tree species including southern magnolia, beech, white oak, southern sugar maple, and American holly. The forest is protected by the steep slopes, down which fire can scarcely spread. The upper-most portions of the bluff contain the drier forest, which may experience infrequent fire.

Important species are southern red oak, shortleaf pine, mockernut hickory, post oak, and dogwood. While the botanical distinctiveness of the ravines has long been established, no terrestrial vertebrates are strictly endemic to this area. The shaded ravines do however contain Florida's greatest abundance of northern streamside salamanders; copperheads and sometimes the one-toed amphiuma. A portion of the ravines has been set aside for protection in the Torreya Florida State Park (Clewell, 1977). The Nature Conservancy has also purchased land near the bluffs. The Conservancy can be considered a "temporary land-holder" in that they purchase lands in imminent environmental danger with the purpose of eventually selling them to a State or Federal agency (Miley, 1985).

LAKES AND IMPOUNDMENTS

Lake Seminole

Lake Seminole is discussed previously under the Chattahoochee River basin Lakes and Impoundments section.

Dead Lakes

Located in Gulf and Calhoun Counties, Dead Lakes was originally a cypress lowhead on the lower Chipola River; receiving discharge primarily from the Chipola River and West Arm Creek as well as several other smaller creeks (Figure 5). The basin is narrow, averaging 1.6 km (1 mile) in width and 24 km (15 miles) in length. The lake has numerous live and dead cypress trees throughout its waters and many large cypress stumps show signs of man's logging activities in the early 1900's. Water level of the lake is highly affected by the Apalachicola River flows via the Chipola Cutoff (Banks, 1984).

There currently exists a dam on the lower lake (S.R. 22, at Wewahitchka) which has an interesting history and still is a controversial local issue. Pre-dam figures of the U.S. Geological Survey (Dead Lakes Quadrangle, 1945) showed the natural lake encompassed approximately 1,482 ha (3,663 acres) at elevation 14 feet mean sea level (MSL). Interest in constructing a dam began in 1954 when a severe drought caused extremely low water conditions. These problems were reportedly compounded by artificially lowered water levels in the Apalachicola River during initial filling of the newly constructed Jim Woodruff Dam (Lake Seminole) at Chattahoochee, Florida (Banks, 1984).

In 1957 the Dead Lakes Water Management District (DLWMD) was created by the Florida legislature. Dam construction began in 1959 and in 1960 an 244 m (800-foot) interlocking sheet pile structure was completed just above the Chipola Cutoff. After failure of the original dam, a new one was constructed in 1962. Dewatering (drawdown) capabilities constructed in the original dam were not reconstructed in the new dam. The sill elevation of the dam was 18.2 MSL and at that elevation the surface area of the lake was approximately 2,707 ha (6,700 acres). The dam did help to alleviate low water conditions, and the fishery was reported to be phenomenal immediately following dam construction (Banks, 1984). During the late 1960's and 1970's excessive growth of noxious aquatic plants began to occur. In addition, many fish camp operators complained about a decline in sportfish harvest. It was concluded these problems were the result of decreased water fluctuation and pollution (Banks, 1984).

In 1974 a water drawdown structure was constructed at the western end of the dam as a cooperative project by Florida Game and Fresh Water Fish Commission (FL G&F), Florida Department of Natural Resources (FL DNR) and DLWMD. The structure was designed to deal with fishery and aquatic vegetation problems by periodically restoring natural low water fluctuation patterns. Unfortunately, the structure failed to allow water levels to drop to the original low levels.

In 1974, 1975, 1976 and 1977 the FL DNR initiated drawdowns on Dead Lakes. In the spring of 1980 the drawdown gates were again opened unofficially. The structure has remained open since the spring of 1980 and presently logs and debris restrict portions of the flow. The DLWMD has obtained a permit from the U.S. Army Corps of Engineers and the State of Florida to completely remove the dam structure; however opponents of the dam removal have the issue in a State court for resolution (Banks, 1984).

Lake bottom substrates consist of mud, clay and sand overlaid with silt and organic detritus. Aquatic vegetation found in the lake includes water nymph (*Najas* sp.), spatterdock (*Nuphar luteum*), smartweed (*Polygonum hydropiperoides*), water hysop (*Bacopa caroliniana*), spike rush (*Eleocharis cellulosa*), bladderwort

(Utricularia vulgaris), cutgrass, pond weed (Potamogeton sp.), St. John's wort (Hypericum fasciculatum), purslane (Sesuvium sp.), pickerel weed (Pontederia lanceolata), and water hyacinth. Dead Lakes has had problems with aquatic weed control, but currently the problems are under control. Problem species include water hyacinths, egeria (Egeria densa), and limnophila (Limnophila sessiliflora) (Banks, 1984; FL G&F, 1982a).

The Florida Game and Fresh Water Fish Commission has accomplished limited sampling on Dead Lakes. In 1964 blocknet sampling efforts showed largemouth bass and chain pickeral dominated the sportfish population. Bluegill, redear sunfish, and warmouth also showed up in good numbers (FL G&F, 1982a).

In 1972 and 1973 sportfish composed 59% and 62% respectively of the population by weight. In 1978 sportfish composed 34% of the total population. Major increases were also noted in nongame species, primarily gizzard shad and spotted suckers (FL G&F, 1982a).

The 1978 fish population studies showed an apparent reduction in largemouth bass. Five years earlier this species composed 17% of the total weight within the fish population, but in 1978 this figure was reduced to 6%. In 1978 bluegill were the most dominant sportfish by numbers; however, redear sunfish was the most significant sportfish in terms of weight and showed an increase in both numbers and weight in harvestable sizes. Morone hydrids were also introduced into Dead Lakes in 1978 (FL G&F, 1982a).

Blocknet sampling in 1981-1982 showed improvements in the fish population structure from 1978. The redear sunfish still continued to dominate the sportfish population. Greater survival was noted for young of the year largemouth bass; and reductions were documented for nongame species (gizzard shad and spotted suckers) (FL G&F, 1982b).

Trends noted in the report include an 80% increase in standing fish crop from 61 kg (55 lbs/a) to 111 kg (99 lbs/a) per hectare with the average number of fish per hectare increasing from 3,250 (1,299/a) to over 37,500 (15,000/a). Also noted was an 87% increase in the weight of harvestable sportfish from 14.6 kg (13 lbs/a) to 27 kg (24 lbs/a) per hectare (FL G&F, 1982b).

Largemouth bass composed 8.25% of the population by weight in 1981, up from 6.13% in 1978. Significant increase in the panfish population was noted, with a total weight increase of 283% from 15.75 kg (14 lbs/a) to 60.75 kg (54 lbs/a) hectare (FL G&F, 1982b).

It appears that the fishing in Dead Lakes is not experiencing a decline when compared to the data gathered in 1978, rather that some significant increases in the fish populations have occurred. When compared to other areas, however, the productivity is low [less than 112.5 kg/ha (100 lbs/a)] due to rapid exchange of water in the system (Banks, 1984).

Recreational fishery utilization information has not been gathered for the Dead Lakes area.

RIVERINE FISHERY RESOURCES

The Apalachicola River has the highest number of freshwater fish species in Florida, and is the largest river in terms of flow in the State. The river supports 86 species of fish belonging to 43 genera and 21 families (Table 1). Zoogeographically the fauna has originated from multiple sources. The Mississippi basin has contributed the largest number of species, through dispersal along the Gulf Coastal Plain, and by stream piracy from the upper Tennessee River basin. From the Atlantic Coast, some species gained access through the southeastern and Gulf Coastal Plain while others entered the headwaters via stream capture from the Savannah River. A few euryhaline marine invaders have penetrated upstream from the Gulf of Mexico. The several endemic species have apparently evolved within the drainage system. A unique physical feature of the Apalachicola River system is the origin of its headwaters far into the Southern Appalachian Mountains and its north-south axis providing an accessible and convenient dispersal route for temperate fauna and flora to move southward to the Gulf of Mexico (Yerger, 1977).

Three species of fishes that are endemic to the ACF basin are found in the Apalachicola River. One is the bluestripe shiner (*Notropis callitaenia*) which prefers habitats of large rivers with a sandy bottom. Consequently, impoundment of river waters removes large areas of suitable habitat for the species. Another, the bandfin shiner (*Notropis zonistius*) inhabits clear water with a rather swift current, often occurring in pools below riffles rather than in the swiftest waters. The bandfin prefers small to medium-large tributaries. The third species, the grayfin redhorse (*Moxostoma* sp.) is an undescribed species usually found in clear to turbid waters, in slow to moderate current, over sand and gravel bottoms with scant vegetation, and occasionally over silt, rubble, and bedrock. It inhabits the main river stem as well as major tributaries of the river (Yerger, 1977).

Other species of importance include the shoal bass and handpaint bluegill (*Lepomis macrochirus*). The shoal bass occurs in moderate to swift current and usually over a rock or bedrock bottom. It is currently found in the Apalachicola, Flint and Chipola (major tributary to Apalachicola) Rivers and is a well-sought sportfish. The handpaint is a melanistic variant of bluegill apparently restricted to the Apalachicola River and St. Vincent Island. This species is known for its striking coloration during breeding season (Yerger, 1977).

The Florida Game and Fresh Water Fish Commission has conducted annual spring creel surveys on the upper Apalachicola River since 1979. Roving creel censuses are taken on the river immediately below the JWLD to a point 7 km (4.5 mi) downstream. Creel surveys from 1979 to 1985 revealed that panfish were the species most taken, with catfish being the next highest. Other species taken include: sunshine bass hybrid (striped bass x white bass), white bass, largemouth bass, striped bass and crappie. The greatest number of total fish caught occurred in 1982 and the lowest total number occurred in 1985. The greatest amount of fishing effort also occurred in 1982 with 57,938 total hours expended. The highest fishing effort also occurred for panfish in all the years. The sunshine bass or *Morone* hybrid has been stocked into the Apalachicola River system since 1975 and has become a significant sport fishery (Ager,1985; FL G&F, 1984, 1985). The striped bass catch is small compared to other species, however it constitutes a very important fishery due to its reaching "trophy" size up to 30 kg (66 lbs) (Crateau, 1985). Further discussion of the striped bass is found in the Anadromous Fish section of this document.

Introduced fish species of the Apalachicola River were almost all originally stocked in the Chattahoochee or Flint rivers in Georgia, except for the carp and striped bass; and are more or less restricted in the Apalachicola River to the area immediately below the JWLD. The species are common carp, grass carp (Ctenopharyngodon idella), white bass, sunshine bass, green sunfish (Lepomis cyanellus), orange-spotted sunfish (Lepomis humilis), flathead catfish (Pylodictis olivaris), yellow perch, and sauger (Stizostedion canadense) (Yerger, 1977).

The diversity of food and game fishes inhabiting the river has attracted a profitable sport fishing industry in the basin. The mainstay of the sport fishery has been the numerous species of centrarchids (basses and sunfishes) indigenous to these waters, the striped bass, the white bass, and catfish. To a much lesser extent the Alabama shad, skipjack herring, mullet, yellow perch and southern flounder are sought by relatively few fisherman. The lower river supports a good sport fishery of panfish and bass (Yerger, 1977; FL G&F, 1982b).

The Apalachicola River had in previous years supported a commercial fishery for sturgeon (Acipenser oxyrhynchus). During the first half of this century catches were large, and available markets like New York made the industry profitable. In the late 1950's the combination of greatly reduced catches and competition from Russian imports resulted in a drastic reduction in this fishery in the Apalachicola River. Since 1984, the State of Florida has prohibited taking of sturgeon (for any reason) due to the drastic reduction in sturgeon populations (Ager, 1985).

An abundance of catfish (both in numbers of species and individuals) in the river has supported a commercial fishery for many decades. On an annual basis, production fluctuates drastically. At the present time the fishery has deteriorated because there are less commercial fishermen as well as less fish overall to harvest. The channel catfish is the most sought after species but white catfish and several species of bullheads are also taken. The State of Florida surveyed (by mail) in 1982 the commercial fishermen licensed in the six counties adjacent to the Apalachicola River. A total of 164 surveys were sent out, 32% surveys were returned. 43% percent of the fishermen's annual harvest was less than 100 pounds of catfish, 37% harvested from 100 to 500 pounds and 20% harvested more than 500 pounds (FL G&F, 1983; Hill, 1985; Ager, 1985).

MOLLUSCAN FAUNA

Of the West Florida river drainages (Escambia to the Suwannee), that of the Apalachicola River contains the largest total number of species of freshwater gastropods and bivalves, the most endemic species and the greatest proportion of endemics to the total fauna. The drainage basin supports over 50 species of mollusks (Heard, 1977).

Of the 20 gastropods (snails), 16 are prosobranchs (i.e. gill breathers) and their adults are more susceptible to pollution and silting than are the air-breathing pulmonates. All the eggs of the gastropods (except for the apple snail (Pomacea paludosa) are deposited into the water and are subject to the variable aquatic environment. The apple snail lays "terrestrial eggs", attaching the eggs to tree limbs, branches and trunks. The pleurocerid snails (Goniobasis spp.) and the vast majority of amblemid and unionid clams are lotic organisms and only rarely occur in standing waters (i.e. natural lakes, and impoundments of streams) (Heard, 1977, 1979).

Eight species of mollusks are considered endemic to the drainage basin and they are: Goniobasis albanyensis, G. athearnia, G. boykiniana, G. catenoides, Lioplax pilsbryi, Elliptio chipolaensis, E. nigella, and Lampsilis binominatus (Heard, 1977). Of these, five are gastropods and the remaining are bivalves (mussels). Six bivalve species are considered by Athearn (1970) as rare and endangered and they are: Elliptoideus sloatianus, Megalonaias neisleri (boykinianan), Alasmidonta triangulata, Lampsilis binominatus, Medionidus penicillatus, and Pleurobema pyriforme. Heard (1976) appends the list to include Anodonta cataracta, A. couperiana, Anodontoides radiatus, Elliptio crassidens, E. nigella, Glebula rotundata, Quincuncina infucata, Strophitus subvexus, and Villosa villosa which are bivalves and the gastropods Goniobasis albanyensis, G. boykiniana, G. catenoides, Lioplax choctawhatchensis, Pomatiopsis lapidaria and Somatogyrus substriatus (Thompson, 1979; U.S. FWS, 1975).

There are several factors that can be attributed to the decline (and some extinction) of the Apalachicola River drainage molluscan populations. Local extinctions and reduced numbers of mussels have involved the concomitant appearance of the introduced Asiatic clam (Corbicula manilensis). The mechanism of this replacement is presently unknown. In addition, habitat alteration (reservoir construction, siltation, pollution, agriculture) in the drainage basin has been a major factor in population reductions (Heard, 1977, 1985).

WILDLIFE RESOURCES

Many terrestrial vertebrates inhabiting the Apalachicola River drainage are unique to it, endemic, or otherwise considered by State, regional or Federal authority as endangered, threatened, rare, of special concern, or status undetermined. A number of geologic physiographic, and biogeographic reasons contribute to the vertebrate species richness of the drainage (Means, 1977).

The Apalachicola River basin supports at least 260 species of vertebrates including 52 mammals, 99 breeding birds (excluding marine and estuarine species), 64 reptiles and 44 amphibians. Birds and mammals found in the drainage are about as numerous as elsewhere in the Gulf Coastal Plain, but it is in the number of species of amphibians and reptiles that the Apalachicola River drainage basin is most noteworthy. The highest species density of amphibians and reptiles in North America north of Mexico occurs in the upper Apalachicola River basin. This results from high numbers of turtles, frogs, salamanders, and especially snakes. Only the lizards are depauperate as a group, probably because of high humidity and rainfall (Means, 1977).

For the following species which occur on the river, survival is potentially or imminently threatened. The one-toed amphiuma (Amphiuma pnoleter) has a restricted geographical range and paucity of individuals probably due to the special nature of the environment in which it lives. This species is found primarily in mucks of a particular quality. These are liquid, amorphous mucks derived from hardwood litter, often in association with cypress and cypress litter. This amphiuma is one of three living species of an entire family of salamanders and seems to have been relatively unchanged for 80 million years. It is considered rare due to its small geographic range, isolated localities (14 known) and unusual habitat type. The species has been reported from the

upper river and suitable habitat appears to occur on the Florida Environmentally Endangered Land (EEL) tract. The Blotched kingsnake (Lampropeltis getulus goini), is a sub-population of the eastern kingsnake and has a distinguishing color pattern. Its range is from Bay to Jefferson Counties and prefers low, wet depressions, bayheads, swamps, roadside ditches and streamsides, supporting dense titi growth (Cyrilla or Cliftonia). It is suspected that this race, found exclusively in this state, probably evolved here. It is considered to be endemic to the Apalachicola River Lowlands (Means, 1977).

The round-tail muskrat (Neofiber alleni) is an endemic species of the Florida peninsula. This is a bog- and pond-inhabitating herbivore that constructs nests and feeding platforms in shallow water. The westernmost known populations of the round-tailed muskrat are from the lower Apalachicola River. These populations and others extending eastward to about the Suwannee River have been recognized as racially distinct N. a. apalachicolae. The species has been declining over the past decade, probably due to habitat deterioration (Means, 1977).

Four turtles living in the mainstream of the Apalachicola and Chipola Rivers are of special importance because they are considered rare, threatened, status undetermined or geographically disjunct. Barbour's map turtle is an endemic species of the Coastal Plain portion of the Apalachicola-Flint-Chattahoochee River drainage system. This species has suffered from human impact by the impoundment of part of its natural range (Jim Woodruff Dam) and by local harvesting of the turtle for food. The alligator snapping turtle (Macroclemys temmincki) has been threatened in the past decade by commercial exploitation. Inhabitating oxbows, sloughs, and tributaries as well as the river mainstream, this is the world's largest freshwater turtle. The Suwannee cooter (Chrysemys concinna suwanniesis) is a large turtle occurring in Florida Gulf coast drainages from Apalachicola River to Tampa Bay. The Suwannee cooter is primarily a herbivore preferring dense growths of Naias and Sagittaris. This species has dramatically declined in numbers throughout its range. The decline can be attributed to two main factors: 1) a general degradation of rivers it inhabits which may have an impact on abundance of food plants; and, 2) harvest of turtles for their highly prized meat. The Florida red-bellied turtle (Chrysemys nelsoni) occurs in the Apalachicola and Chipola Rivers. This species is disjunct across the Ochlockonee, St. Marks-Wakulla, Aucilla-Wacissa, Econfina and Fenholloway Rivers, occurring again in the Suwannee River and throughout peninsular Florida (Means, 1977).

The Marianna Lowlands, long recognized as a distinctive physiographic unit of the Gulf Coastal Plain, contains more vadose cave ecosystems than anywhere else throughout the entire coastal plain of the United States. The most distinctive faunal element of this biotic unit is the endemic cave-adapted Georgia blind salamander (Haideotriton wallacei) and the crayfish (Cambarus cryptodytes). The air passages of caves in the region support a varied bat fauna including two endangered species, the Gray bat (Myotis griscescens), and Indiana bat (Myotis sodalis) and one rare species Keen's bat (Myotis keeni). Another rare vertebrate found is the flatwoods salamander (Ambystoma cingulatum). Major threats to this ecosystem are impacts from pollution (municipal waste effluents, siltation, and turbidity due to surface erosion in open recharge areas) and alteration of the water table (impounding local streams including the Apalachicola and Chipola Rivers or heavy drawdowns caused by wells). Serious consideration should also be given to these influences on the local water tables (Means, 1977).

The gopher tortoise demonstrates an interactive association of how animals are dependent upon or influenced by other species in one way or another for food or shelter. The gopher tortoise excavates one or more extensive burrows in its lifetime which provides shelter used from occasionally to almost obligately by other vertebrates. Species commonly found utilizing the burrows include rattlesnakes, Indigo snake (Drymarchon corais), Florida pine snake (Pituophis melanoleucas mugitus), and Florida gopher frog (Rana areolata aesopus). Everywhere throughout its range the gopher tortoise has experienced reduction of its natural habitat, which consists of well drained sandy soils originally supporting longleaf pine-turkey oak-wiregrass or sandhill scrub vegetation. The greatest threat to the survival of the gopher tortoise and its associates is the loss of habitat. With an increasing human population in Florida and elsewhere the tortoise has suffered loss of habitat to agriculture, silviculture (especially to site preparation and closely spaced replanted pines), and urban and suburban development including construction of roads, airports, town and cities. In addition the gopher tortoise is considered a delicacy and is commonly taken for food. Another threat to the gopher tortoise association probably having a much more serious impact on the associated vertebrates and invertebrates than the tortoise itself is the use of gasoline and its fumes for the purpose of evicting rattlesnakes. The fumes have been shown to seriously debilitate or actually kill not only rattlesnakes but the other inhabitants as well. Extirpation of the threatened gopher tortoise almost assures the loss of or an impact on at least three other species and definitely insures loss of the obligate invertebrates (Means, 1977).

There are many reasons for the biogeographic phenomenon found in the Apalachicola River drainage. First, no geographical area can support high diversity in any organismal group without a correspondingly high diversity of the physical environment which the basin has. Second, a large species pool must be available in adjacent geographic regions from which to recruit species. The basin is strategically located in the southeastern United States to receive faunal and floral elements from four major adjacent areas of endemism (from the north, the Atlantic Coastal Plain, the Gulf Coastal Plain, and peninsular Florida) (Means, 1977).

The species inhabiting the Apalachicola drainage that are basically northern animals are three salamanders (Desmognathus fuscus, Hemidactylium scultatum, Pseudotriton triseriata), and two snakes (Regina septemvittata, Agkistrodon contortrix). Those species having predominantly Atlantic Coastal Plain distributions are one salamander (Siren lacertina), one frog (Limnaeodus ocularis), and two snakes (Natrix taxispilota, Seminatrix pygaea). The Gulf Coastal Plain contributes the same number of species as the Atlantic Coastal Plain; these are one salamander (Necturus beyeri), one frog (Hyla avivoca), one turtle (Macro clemys temmincki), and one lizard (Eumeces anthracinus). Peninsular Florida contributes one salamander (Pseudobranchus striatus), two turtles, (Trionyx ferox), (Chrysemys nelsoni), one snake, (Drymarchon corais), and one lizard (Eumeces egregius) (Means, 1977).

Only two species are strict Apalachicola endemics, a cavernicolous salamander (Haideotriton wallacei) and Barbour's map turtle. However, the Apalachicola River drainage contains two other species whose geographical distributions are primarily focused on the Apalachicola River basin, but which range somewhat beyond. These are classed as "regional endemics" and are the two salamanders, Amphiuma pholeter and Ambystoma cingulatum. The remaining 32 amphibians and 52 reptiles are categorized as either widespread Coastal Plain or widespread eastern United States (Means, 1977).

Because the climate is mild and the physical diversity relatively high, the Apalachicola River drainage basin supports a moderately large complement of species that are wide-ranging both throughout the eastern United States and in the Coastal Plain. The species density is due in part by the adjacent four regions having faunal distinctiveness of their own and a number of species' ranges end in the Apalachicola River drainage. Thus, there is overlap in this drainage of Gulf Coastal Plain species whose easternmost distribution is in the Apalachicola River drainage and Atlantic Coastal Plain species whose westernmost distribution terminate here. Further, several northern species find their southernmost distributional limits in the Apalachicola River basin while a few peninsular Florida forms extend their northwestern limits into the basin. All these factors in combination result in the highest species density of amphibians and reptiles in North America north of Mexico. The Apalachicola River drainage basin is truly a crossroads where physiographic changes take place and biotas meet (Means, 1977).

The bird life of the Apalachicola River is abundant and diverse, the floodplains providing a multitude of habitats. The mesic habitats with relatively low environmental stress contributes to the diversity and abundance of feed and fruit producing plants as well as insects heavily utilized by birds. The Apalachicola River floodplain forest is an important bird habitat both for resident, breeding and wintering birds. The river also serves as a "highway" for migration. In addition to its value for forest species, the sloughs, ponds, and terrace streams provide feeding areas for a number of wading birds such as the great egret, great blue heron and little blue heron. Wintering birds to be found include yellow-rumped warbler (Dendroica coronata), American goldfinch (Carduelis tristis), American robin, ruby-crowned kinglet (Regulus calendula) and yellow-bellied sapsucker (Sphyrapicus varius). Species found in wet thickets are prothonotary warblers, yellow-throated warbler (Dendroica dominica), hooded warbler (Wilsonia citrina), common yellow throat (Geothlypis trichas), and yellow-breasted chat (Icteria virens). Another bird of fairly restricted habitat within the lower levels of the bottomland hardwoods is the Swainson's warbler (Limnothlypis swainsonii). The canebrakes along the river can be expected to harbor this inconspicuous warbler because they support leaf litter insects as crickets, ground beetles, ants, and spiders which form a major portion of the warbler's diet. The Swainson's warbler can also be found in areas of scrub palmetto and sweet pepperbush. Canopy users of the floodplains include most of the woodpeckers, blue jay (Cyanocitta cristata), Carolina chickadee (Parus carolinansis), and tufted titmouse (Parus bicolor). Midstory species include Carolina wren (Thryothorus ludovicianus), white-eyed vireo (Vireo griseus) and hooded warbler. Heavy ground users to be found are rufous-sided towhee (Pipilo erythrophthalmus) and white-throated sparrow (Zonotrichia albicollis) (Means, 1977).

The wood duck, a hole-nesting resident as well as a migratory waterfowl, is also found extensively in the bottomlands and is dependent on the availability of sloughs, ponds, and trees with suitable nest cavities. Birds of special emphasis (endangered, threatened, rare, etc.) occurring or expected to occur in the floodplain forests include the bald eagle, osprey, peregrine falcon (Falco peregrinus), American kestrel (Falco sparverius), American redstart (Setophaga ruticilla) and the Louisiana water thrush (Seiurus motacilla). The northern part of the Apalachicola River may be one of the southernmost extensions of breeding territory for the Louisiana thrush. The river floodplain also provides habitat for the wild turkey; estimates of density are one turkey per 32 acres of the more mesic portions of the floodplain (Means, 1977; Miller et al., 1977).

The floodplain habitats of the Apalachicola River also support a good mammal population. The white tailed deer is a common and sometimes abundant resident with densities ranging from one deer per 10-12 acres, to one per 80 acres. River swamps not only provide high quality food sources but also serve as excellent escape cover from hunters and free-ranging dogs. The grey squirrel reaches its maximum densities in the swamps and hammocks of the riverbottom with densities often approaching one per acre. Other fairly common mammals recorded in the Apalachicola River floodplain include opossum, marsh rabbit (Sylvilagus palustris), beaver, cotton mouse (Peromyscus gossypinus), southern golden mouse (Ochrotomys nuttalli), cotton rat (Sigmodon hispidus), woodrat (Neotoma floridana), raccoon, grey fox and striped skunk. Bats heavily utilize the floodplain and the corridor over the channel as feeding areas. Several species also roost in tree cavities. Typical species are the red bat (Lasiurus borealis), evening bat (Nycticeius humeralis), seminole bat (Lasiurus seminolus), eastern pipistrelle (Pipistrellus subflavus), Indiana bat and gray bat (Miller et al., 1977).

Endangered or threatened large mammals that may be found in the area include the State listed black bear and possibly the Federal listed panther (Felix concolor coryi). The extent of the floodplain and its function as a contiguous corridor for large mammal movements make this area of potential habitat for either of these wide ranging animals (Miller et al., 1977).

The Apalachicola River drainage basin is a popular recreational hunting area. Species to be taken include the white tailed deer, turkey, bobwhite quail, gray squirrel, rabbit, fox squirrel and wild hog, dove, wood duck, and woodcock (Miller et al., 1977; Wright, 1985).

Commercial harvesting of furbearers also occurs in the Apalachicola River basin. The State of Florida regulates the process, requiring the harvester to obtain a furbearers license and sell skins and pelts to licensed fur dealers. The fur dealers are then required to submit reports to the State. Species taken for the 1984-85 season (in descending order of numbers taken) are raccoon, otter, oppossum, bobcat, mink and beaver. No nutria or skunk were reported taken. This information is for State totals or regions, no specific information is available for basin or counties. According to the 1984-85 State Furbearer Status Report the value of fur remains substantial and the license sales data continues to reflect the interest (Goodwin, 1985; Spratt, 1985).

STATE AND FEDERAL WILDLIFE MANAGEMENT AREAS

There are five State of Florida Wildlife Management Areas (WMA) bordering the Apalachicola River, and the Florida Game and Fresh Water Fish Commission has the management responsibility for the WMA's.

Apalachicola Wildlife Management Area

The Apalachicola WMA consists of 226,000 ha (559,000 a) in Gulf, Liberty, Franklin, and Jackson Counties. The WMA is part of the Apalachicola National Forest and is actively managed by the U.S. Forest Service. FL G&F contributes to the Forest management by participating in annual prescribed burnings (for wildlife management), conducting wildlife population surveys (includes wading birds), monitoring the endangered red-cockaded woodpecker populations, conducting deer track counts, managing public hunts and maintaining public camping areas. Public hunting is conducted to the maximum

of what is allowed by the State. In the Apalachicola River basin, this is the only WMA where bear hunting occurs. Current deer population estimates for the WMA is 1 deer per 61 ha (1 deer per 150 acres) (Smith, 1986). WMA offers deer, wild hog, and black bear hunting (Trainor, 1986).

Edward Ball Wildlife Management Area

The Ed Ball WMA encompasses 13,200 ha (32,680 a) in Gulf County. The lands are privately owned by the St. Joe Paper Company but are managed for wildlife by FL G&F involving annual prescribed burnings and planting of food plots. Public hunting is allowed on the WMA for a portion of the regular hunting season (Smith, 1986). Hunting in the WMA is mostly for deer (Trainor, 1986).

G.U. Parker Wildlife Management Area

The G.U. Parker WMA is located in Gulf and Calhoun Counties consisting of 8,140 ha (20,124 a). The WMA is privately owned by Neal Land and Timber Corporation and is essentially a public hunting and recreational area where the private owner accomplishes the majority of habitat management for wildlife. FL G&F does however survey the wildlife populations and manages the public hunts which are open for only a portion of the hunting season. Population estimates show a high deer population of 1 deer per 10 ha (1 deer per 25 acres) on the WMA (Smith, 1986). Squirrel hunting is excellent, and there is a low wild hog population (Trainor, 1986).

Joe Budd Wildlife Management Area

The Joe Budd WMA is State owned land managed jointly by FL G&F and Division of Forestry. Forestry manages the timber production while FL G&F manages extensive wildlife food plots, annual prescribed burnings and public hunts. Public hunting is restricted to Friday, Saturday and Sunday during archery and muzzle loading seasons only. Population estimates show a high deer density of 1 deer per 5 ha (1 deer per 11 acres) on the WMA (Smith, 1986). Hunting for dove, small game, turkey and deer occur on the WMA (Trainor, 1986).

Robert Brent Wildlife Management Area

Robert Brent WMA is under private ownership of St. Joe Paper Company but managed by FL G&F consisting of 32,680 ha (80,750 a) in Gadsden and Liberty Counties. Intensive management efforts are not accomplished on the WMA except for monitoring of wildlife populations and operating public hunts which are allowed throughout the hunting season (Smith, 1986). Primary species hunted include deer, wild hog, turkey and squirrel (Trainor, 1986).

Public Use of WMA's

Total deer harvest for the 1984-1985 season in the management areas was 710 deer taken. Turkey hunting figures showed 173 turkeys taken during the same season. Thirty-four black bear were taken from the Apalachiola WMA. Only ten ducks were reported taken for all the WMAs, probably wood duck. Dove hunting numbers reported were also low with only 45 doves taken for the entire WMAs. Quail and rabbit numbers were low with six and 24 respectively being taken. Squirrel are a highly sought game animal in the lower Apalachicola River and an estimated 1,500 hunters invade this area each year, on the opening day of hunting season. Approximately 3,545 squirrel were harvested in the 1984-1985 season. Approximately 259 raccoon were harvested and four bobcats taken in the WMA's. Only

one woodcock was reported harvested during the season. Approximately 26,300 hours were expended hunting on the WMAs during the 1984-1985 season. Apalachicola WMA received the most pressure with 12,716 man/hours (Miller, et al., 1977; FL G&F, 1985; Wright, 1985).

Apalachicola National Forest

The Apalachicola National Forest (ANF) covers 226,100 ha (558,700 acres) in Franklin, Leon, Liberty, and Wakulla Counties, Florida. The ANF is managed by the U.S. Department of Agriculture, Forestry Service with cooperation from the FL G&F (USDA, 1985a).

The ANF contains portions of six watersheds, one of which is the Apalachicola River. In addition to the streams, there are 1,106 ha (2,735 acres) of lakes. Wetlands and other riparian areas make up 119,250 ha (294,678 acres) occupying irregularly-shaped, shallow depressions that generally do not join to form drainages (USDA, 1985a).

The Forest terrain is flat to gently rolling and pocked by numerous sinkholes. The pine types range from the higher longleaf pine sites to the longleaf and slash pine flatwoods. There is some loblolly pine in the bottoms of the main streams and pond pine on wet sites. The pine flatwoods are interrupted frequently by bay-titi swamps which support cypress, titi, sweetbay, black gum, juniper, and other southern hardwoods. An understory of turkey oaks, scrub oaks, and grasses is usually associated with longleaf pine types, and palmetto, gallberry, and other shrubs comprise the understory associated with the longleaf/slash pine types. The savannahs, wet grassy areas with no trees or large shrubs, occur on the western half of the Forest; savannahs host the most diverse collection of wildflowers in the continental United States, including several varieties of orchids, lilies, and insectivorous plants (USDA, 1985a).

The ANF is home to a wide variety of wildlife and fish. Game animals on the Forest include white tailed deer, black bear, wild turkey, quail, dove, rabbit, and squirrel. Nongame species on the Forest include over 65 species of fish and 45 species of mammals. The Forest provide suitable habitat for numerous rare, threatened, or endangered animal species. The entire Forest provides habitat for the endangered red-cockaded woodpecker, and the western half of the Forest has perhaps the densest population of this bird in the world. Other endangered or threatened wildlife species include the American alligator, the indigo snake, the bald eagle, the wood stork, gray bat, Florida panther, and the gopher tortoise (USDA, 1985a).

The Apalachicola River basin has a wealth of plant species indigenous only to the panhandle region of Florida, including the endangered Harper's Beauty which is found only on the Forest. At least another 21 species of plants which occur or probably occur on the Forest are under review for federal listing including southern milkweed, pine-woods aster, coastal-plain-wild-indigo, mock penny royal, thick-leaved water willow, white bird-in-a-nest, Ashe's magnolia, Florida beargrass, Carolina-grass-of-parnassus, violet-flowered meadow beauty, and Chapman's crown beard (USDA, 1985a).

The ANF contains two wilderness areas: 1) Bradwell Bay Wilderness Area designated in 1975 and enlarged by the Sopchoppy River addition in 1984; and, 2) the Mud Swamp - New River Wilderness Area designated in 1984 (USDA, 1985a).

APALACHICOLA BAY AND ESTUARY

ENVIRONMENTAL/GEOGRAPHICAL SETTING

The Apalachicola Bay and estuary is the termination of the ACF system (Figure 6). It is a lagoon and barrier island complex and has been classified as a shallow Coastal Plain estuary (Dawson, 1955). The Apalachicola Bay system is a width-dominated estuary controlled by lunar tides and wind currents (Pritchard, 1967).

The entire estuarine area totals 62,879 ha (155,374 acres). A natural shoal forms a submerged boundary between Apalachicola Bay and St. George Sound. The bay is bounded on its extreme southern end by three barrier islands: St. Vincent, St. George Island (including Little St. George Island), and Dog Island. There are four natural openings to the gulf: Indian Pass, West Pass, East Pass, and a pass between Dog Island an Alligator Harbor. A man-made opening (Sike's Cut) was established in the western portion of St. George Island in the mid 1950's (Livingston, 1984c).

As a biological entity (Odum et al., 1974), the estuary (which includes East Bay, Apalachicola Bay, St. Vincent Sound, and western portions of St. George Sound), is characterized by marshes that grade into soft-sediment areas, vegetated shallow bottoms, and oyster reefs. The oligohaline East Bay merges with mesohaline and polyhaline portions of Apalachicola Bay, St. Vincent Sound, and St. George Sound.

The Apalachicola basin occupies the last sparsely inhabited and undeveloped drainage system and coastal region in Florida (Livingston, 1983a, 1983b, 1983c). Franklin County, with a population of only 8,403 in 1979, encompasses the lower river and bay system. Forested uplands, wetlands, and aquatic habitats comprise most of the land area in Franklin County.

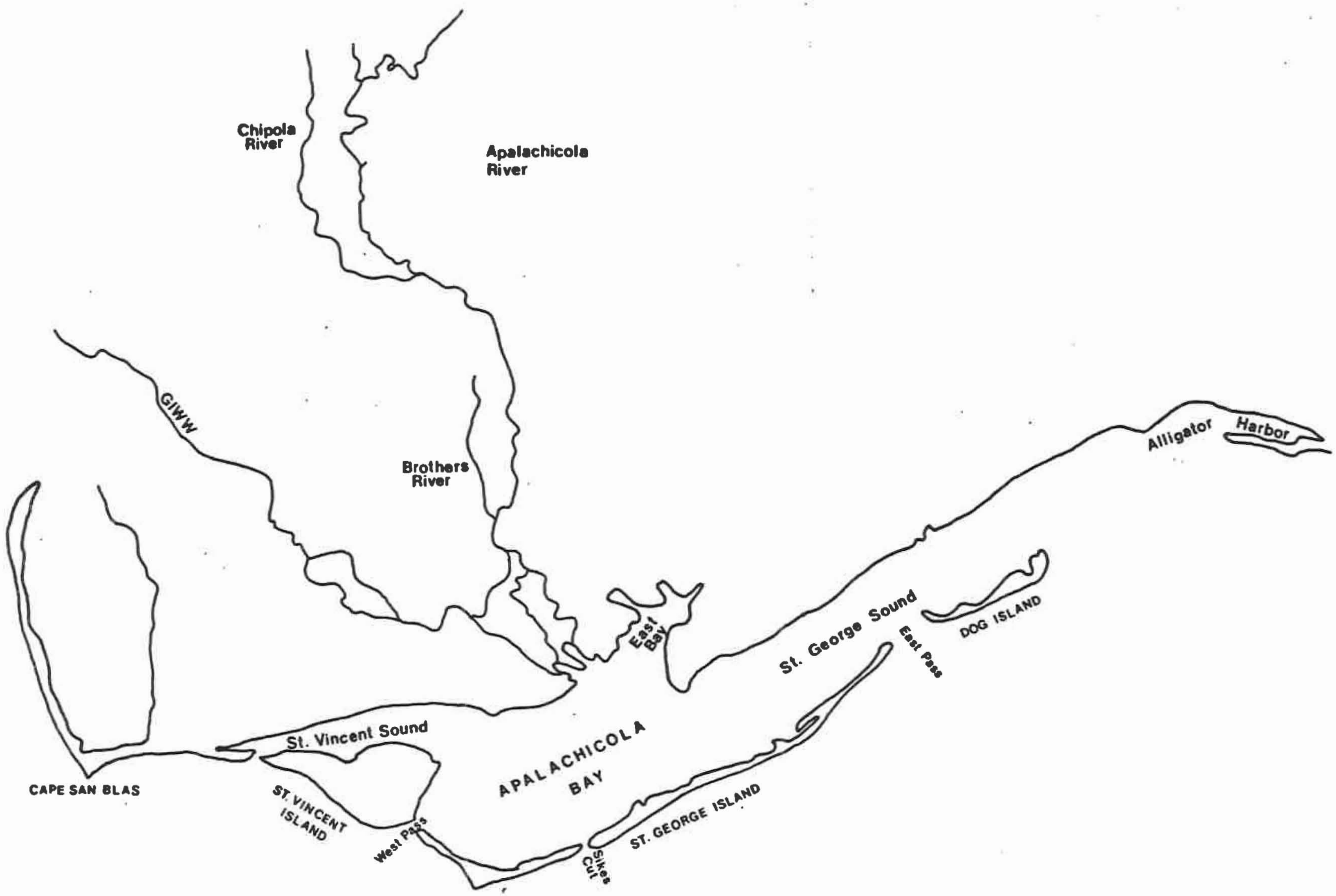
PHYSICAL/CHEMICAL PROPERTIES

The Apalachicola River is the principal source of fresh water to the estuary. The river and secondarily, local rainfall determine the distribution of salinity in the estuary. The placement of the barrier islands also has a major influence on the salinity regime of the estuary limiting the outflow of the low-salinity water to the outer Gulf of Mexico (Livingston, 1979, 1984a).

The tides at Apalachicola Bay are mixed, i.e., a type of tide with a large inequality in either the high and/or low water height, with two high waters and two low waters occurring each tidal day. In actual fact, all tides are mixed but the term "mixed tide" is usually applied to tides intermediate to those predominantly semidiurnal and those predominantly diurnal (Hicks, 1984, Isphording, 1985).

While currents in the Apalachicola estuary are tide-dominated, they are also dependent on local physiographic conditions and wind speed and direction (Livingston, 1978). River discharge has little influence on the hydrodynamics of the partially stratified estuary (Conner et al., 1981). Shallow estuaries such as the Apalachicola are wind dominated in terms of flushing and current movement. The wind can be up to three times more important than the tidal input in the determination of current strength and direction (Conner et al., 1981).

Figure 6: Apalachicola Bay and Estuary.



Net flows tend to move to the west from St. George Sound; East Bay water merges with the westward flow. West Pass appears to be a major outlet for the discharge of estuarine water to the Gulf, especially when influenced by long-term or high velocity winds from the east. Water movement through Indian Pass also occurs in a net westward direction (Dawson, 1955). Estuarine currents may also be affected by excessive land runoff from the east or west.

Gorsline (1963) estimated a tidal prism equal to about 20% of the bay water volume, and he suggested that the residence time of river water in the estuary ranges from a few days to a month. The two western passes account for over 66% of the total bay discharge (Gorsline, 1963). Tidal deltas extend seaward from Indian Pass, West Pass, and East Pass, indicating appreciable sediment transport through these areas. Current velocities in the bay rarely exceed 0.5 m/sec, while velocities in the passes may reach 2-3 m/sec (Livingston, 1984c).

Because of the shallowness of the bay system and wind-mixing of the water column, there is little thermal stratification in the estuary. Summer temperature peaks are similar from year to year, with seasonal highs usually in August. Water temperature minima occur from December to February and monthly variance is highest during winter. Whereas peak summer temperatures are comparable from year to year, winter minima vary annually. In addition to strong seasonal components of changes in water temperature, periodic winter lows occurred at relatively regular (8-11 yr) intervals (Livingston, 1984c). Recent investigations (Isphording, 1985) show highest temperatures found in the estuary are in St. George Sound and the shallow waters of East Bay. Bulkhead shoal appears to exert a controlling influence blocking summertime warmer waters from St. George Sound from easily entering Apalachicola Bay.

In terms of salinity, the bay system may be divided into two main provinces: the open Gulf waters of eastern St. George Sound and the brackish portions of western St. George Sound, Apalachicola Bay, East Bay, and St. Vincent Sound. Mean salinity values are lowest at the mouth of the river and in East Bay.

The lower reaches of the Apalachicola River are brackish, with salinities reaching 0.5 parts per thousand (ppt). During periods of high river flow, the zone expands to include East Bay and considerable portions of Apalachicola Bay. East Bay, lying northeast of the river head, is oligohaline (0.5-5.0 ppt) during most of the year. Apalachicola Bay, St. Vincent Sound, and western portions of St. George Sound vary between mesohaline (5-18 ppt) and polyhaline (18-30 ppt) conditions, depending on river flow and upland runoff (Livingston, 1983d). Areas near the passes and in the eastern sections of St. George Sound vary from polyhaline to euhaline (30 ppt) conditions. Vertical salinity stratification has been documented in various parts of the estuary, especially in areas affected most directly by the river, with differences of surface and bottom salinities of as much as 5-10 ppt (Livingston, 1978, 1984a). Isphording (1985) found that St. George Sound displayed local variation in bottom versus surface salinity due to the channeling effect of the oyster bars and sand bars within the sound. There are persistent seasonal patterns of salinity in the Apalachicola estuary, although such patterns are modified by river flow and local rainfall. Low bay salinities coincide with high river flows during winter and spring periods; secondary salinity reductions occur in the bay system during late summer-early fall periods of high local precipitation. Salinity generally peaks during the fall drought (October-November) (Livingston, 1984c).

Maximum levels of dissolved oxygen usually occur during winter and spring months because of low water temperature and, to a lesser degree, low salinity. During summer and fall periods, vertical stratification of dissolved oxygen is evident in various parts of the estuary. Spatial distribution of mean dissolved oxygen values is not uniform; the highest values occur in the upper reaches of East Bay (i.e., Round Bay), just off St. George Island (i.e., Nick's Hole), and along the eastern side of St. Vincent Island (Livingston, 1984c). Isphording (1985) did not observe any significant low oxygen water in the bay system, although samples were taken from September to October.

From 1972 to 1982, the pH throughout most of the bay system ranged between 6 and 9 (Livingston, 1983c, unpublished data). However, relatively low pH levels (4-5) were observed in upper portions of East Bay during periods of heavy local rainfall where runoff from newly cleared lands in Tate's Hell Swamp occurred (Livingston, 1978). Such changes were temporary and, overall, the pH of the Apalachicola Bay system remains within a range that is not limiting to most life forms. Isphording (1985) also found that the pH ranged between 6 and 9 and no values lower than 7.0 were observed.

The highest levels of water color and turbidity are found at the mouth of the river and throughout upper East Bay with clear-cut gulfward gradients. Both color and turbidity reach seasonal high levels during winter and early spring periods of high river flow and overland runoff. While the general pattern of color in the estuary follows river flow fluctuations, Livingston (1978) found the highest levels occurred in eastern East Bay. The color was directly associated with forestry activities and runoff from the Tate's Hell Swamp. Various compounds such as tannins, lignins, and fulvic acid complexes, which occur naturally in the upland swamps, are washed into the estuary during periods of high local precipitation. Isphording (1985) found high turbidity concentrations at the entrance to St. Vincent Sound, just west of Green Point, near the northeastern edge of St. Vincent Shoal and in an area about 6.4 km (4 mi) southeast of the mouth of the Apalachicola River. The high readings may indicate that suspended material carried into the bay from the Apalachicola River may be at least initially carried southeastwardly to an area approximately one to two miles west of Bulkhead Shoal. Westward directed tidal currents operating in St. George Sound would later act to distribute the material farther west throughout Apalachicola Bay. Lowest turbidity values observed during the same investigation were found throughout St. George Sound and at the southwestern corner of Apalachicola Bay, near West Pass. These low values are a direct consequence of depositional patterns and the lack of fine sediment sources in both areas (Isphording, 1985).

BIOLOGICAL HABITATS

Most of the intertidal areas around the estuary are surrounded by freshwater, brackish, or saltwater marshes. The freshwater and brackish-water marshes are characterized by bullrushes, cattails, sawgrasses, cordgrass, and black needlerush (*Juncus roemerianus*). Salt marshes of the region are represented by black needlerush, cordgrass, saltgrass (*Distichlis spicata*), and glasswort (*Salicornia* spp). The majority of the the marshes are found along the lower portions of the river with narrow stands of brackish water marshes occurring intermittently along the bayside portion of the barrier islands. Limited marshes are also located along the mainland east and west of the Apalachicola River mouth. The East Bay marshes dominate the system by area with lesser

marsh development along St. Vincent Sound and along the lagoonal portions of St. George Island and Dog Island. The marshes in the entire bay system comprise approximately 14% of the total water surface (Livingston, 1984c).

The marshes, which include complex patterns of tidal channels and small creeks, provide food and habitat for a number of organisms in the Apalachicola estuary. Marsh complexes include insects, mollusks, crustaceans, fishes, birds, and mammals. Topminnows of various species are dominant in such areas. Many species that are important to sports and commercial fisheries of the region spend at least part of their life histories in the estuarine marshes. Such species include blue crab, penaeid shrimps, largemouth bass, lepomids, striped mullet, spotted and sand seatrout, and anchovies. Few species spend their entire lives within the marshes, however, and the marsh habitat is best characterized as a nursery for migratory species during summer and fall months (Livingston, 1984c).

Submerged grassbeds in the Apalachicola estuary account for about 10% of the total water area. Except for certain areas along the eastern portions of St. George Sound, submerged vegetation in the Apalachicola estuary is light-limited by high turbidity and water color. High sedimentation and resuspension of sediments in the estuary may also affect the seagrass bed distribution. Seagrasses are largely confined to fringes of the estuary at depths of less than 1 m (3.28 ft). The largest concentration of these submerged grassbeds is in eastern St. George Sound; other seagrass beds also occur in upper East Bay, inside St. George Island in Apalachicola Bay, and in western St. George Sound. In East Bay, freshwater and brackish-water species consisting of tape grass (Vallisneria americana), widgeon grass (Ruppia maritima), and pond weed (Potomogeton sp.) are predominant. In recent years, some parts of East Bay are being taken over by Eurasian watermilfoil. During the period 1980-1981, this introduced species became dominant in Round Bay, one of the eastern bayous. By 1982-1983, the Myriophyllum had become rooted throughout the upper East Bay area (Livingston unpubl.) Grassbeds along the mainland east of the river are dominated by shoal grass (Halodule wrightii), manatee grass (Syringodium filiforme), and turtle grass (Thalassia testudium). The shallow lagoonal flats off Alligator Point, Dog Island, and St. George Island are populated by shoal grass and manatee grass. Few if any grassbeds are found in St. Vincent Sound (Livingston, 1984c).

Even though the submerged grassbeds are limited to only a small portion of the aquatic area by the high turbidity and sedimentation associated with the river, the productivity of the submerged seagrass habitat is high.

The brackish-water seagrass beds serve as a nursery for benthic species such as the gastropod mollusc, Neritina reclivata (a major dominant) and epibenthic species (Odostomia sp., Gammarus macromucronatus and Taphromysis bowmani). Infaunal assemblages are dominated by polychaetes (Loandalia americana, Mediomastus bonnieroides) and chironomid larvae (Dicrotendipes sp.). Fish populations are dominated by rainwater killifish (Lucania parva), pipefish (Syngnathus scovelli), silversides (Menidia beryllina), gobies (Microgobius gulosus), and centrarchids when the salinities are zero (Duncan, 1977; Livingston and Duncan, 1979; Purcell, 1977). Of the 28 dominant benthic species of fishes that comprised over 98% of the abundance in the area, most consume detritus, small mollusks, crustaceans, epiphytes, and insect larvae. Most of the penaeid shrimp, insect larvae, and fishes that are found here are seasonally abundant at early stages of their reproductive cycles, which indicates the use of these areas as primary nursery grounds. In the higher salinity grassbed areas

epifaunal macroinvertebrates, dominated by Hargaria rapax, Ampelisca vadorum and infaunal Heteronmastus filiformis and various "oligochaetes" are found, reaching peaks of abundance during early spring. Predominant fishes include silver perch (Bairdiella chrysoura), pigfish (Orthopristis chrysoptera), pinfish (Lagodon rhomboides) and spotted seatrout (Cynoscion nebulosus). These species are abundant from May through September. Blue crabs (Callinectes sapidus), pink shrimp (Penaeus duorarum) and grass shrimp (Palaemonetes vulgaris) are the dominant invertebrates. Their densities are bimodal, peaking in the winter and summer months. The grassbeds are also characterized by the year-round presence of larval and juvenile nekton.

Muddy, soft bottom substrates comprise about 78% of the open water zone of the Apalachicola Bay system and are thus the dominant habitat form in the estuary. The relative composition of the sand, silt, clay and shell fractions of the sediments depends on proximity to land, runoff conditions, water currents, and trends of biological productivity. Sediment type and associated water-quality conditions in the benthic habitat determine the composition of infaunal and epifaunal biological components (Livingston, 1984c).

The muddy bottom substrate is inhabited primarily by polychaetes (Mediomastus ambiseta, Steblospio benedicti) and amphipods (Grandidierella bonnieroides). The polychaetes are deposit and suspension feeders with a high reproductive capacity and considerable tolerance for low salinity and variable environmental conditions. Areas around the mouth of the river have much higher numbers of infaunal macroinvertebrates than areas outside of the region of general flow. Such differences have been attributed (Livingston, 1983c, 1983d) to the deposition of nutrients and detritus by the river during periods of flooding, and increased activity and abundance of the benthic macroinvertebrates.

The general community characteristics of these soft-bottom assemblages change temporarily and spatially. In mesohaline and polyhaline portions of the system, overall numerical abundance is lower than in oligohaline areas, but species richness and diversity increase significantly (Livingston et al., 1983). Such trends are evident in the associations of epibenthic fishes and invertebrates, which are an important part of the soft-sediment communities. Dominant populations such as Atlantic croaker, spot, penaeid shrimp, and blue crabs feed extensively on organisms within the muddy bottom of the estuary.

The Apalachicola estuary is an ideal environment for the growth and culture of the American oyster (Crassostrea virginica) with oyster beds covering about 7% of the aquatic area of the bay system. Major oyster beds are located in St. Vincent Sound, west St. George Sound, and the East Bay-Apalachicola Bay complex. New oyster reefs are located in eastern portions of St. Vincent Sound (Livingston, 1984c). Oyster bars, themselves, provide habitat and food for a variety of organisms. The oyster associated community includes sponges (Clinoa vastifica), bryozoans (Membranipora sp.), flatworms (Stylochus frontalis), annelids (Neanthes succinea, Polydora websteri), various arthropod crustaceans (Callinectes sapidus, Menippe mercenaria, Neopanope spp., Petrolisthes armatus), gastropods (Crepidula plana, Melongena corona, Thais haemastroma, and pelecypods (Brachidontes exusta, Chione cancellata) (Menzel et al., 1966). Fishes include blennies (Hypsoblennius spp.) and toadfish (Opsanus beta). These organisms use the reef for shelter and/or feeding.

The shallow nearshore Gulf is characterized by moderately high-energy sand beaches. The sands and clays off the Apalachicola embayment grade into sand and mud over limestone characteristic of the extreme eastern gulf region. The high-salinity coastal waters are well mixed except during warmer months when a thermocline separates the cooler bottom waters from the surface waters.

Organisms in nearshore areas are part of a temperate sand community (Jones et al., 1973; Smith, 1974). The shallow (10-20 m) shelf benthos reflects the intrusion of tropical species in both sandy areas and rocky outcrop substrates. The northeastern Gulf lies in the Carolina Zoogeographic Region with a warm-temperate fish fauna. Fish assemblages are characterized by high endemism and high species diversity with the northeastern Florida gulf coast has a relatively high fishery potential for crustaceans and finfishes (Jones et al., 1973, Smith, 1974).

PRODUCTIVITY

The largest detrital contributor to the nutrient pool of the bay is from the Apalachicola River floodplain. Nutrients are transported to the estuary both in the form of detritus (organic particulate matter such as leaves and twigs) and as compounds dissolved in the water column. Annual flooding causes surges in nutrient transport, and these nutrients are the foundation for estuarine productivity. Nutrients transported from the Apalachicola River floodplain to the estuary are especially important since detritivores occupy key positions in the bay's food web (Livingston, 1982b; Leitman et al., 1981).

Meeter et al. (1979) found the cyclic productivity of Apalachicola Bay depends upon both annual pulses of detritus and the large scale import of detritus during 5 to 7 year pulses in increased flow. They found these pulses to be linked to peaks in commercial seafood catches in the bay. Therefore, the influence of the floodplain on Apalachicola Bay extends beyond the 1 to 2 year flood zone (Wharton, et al., 1977). Since Jim Woodruff Dam restricts particulate flow from the Chattahoochee and Flint rivers, the Chipola and Apalachicola floodplains are the primary contributors of detritus to the bay. However, outflow at Jim Woodruff Dam does contain a substantial nutrient load in a dissolved form (Elder and Cairns, 1982). Elder and Mattraw (1982) found that outflow from Jim Woodruff Dam is the largest single contributor of nutrients in the dissolved form to Apalachicola Bay.

Compared to the ACF system as a whole, the Apalachicola floodplain is extremely high in nutrient yield per unit area, especially for carbon and phosphorus. Mattraw and Elder (1982) postulated that the upper Chattahoochee/Flint watersheds yielded fewer nutrients because the 16 reservoirs act as nutrient retention ponds. Although headwater inflow provides substantial loads of dissolved nutrients to the estuary, particulate matter delivered from the river is derived almost exclusively from the Apalachicola/Chipola wetlands. Approximately 16% of the organic carbon delivered to the estuary is derived from less than 1% of the ACF basin (Mattraw and Elder, 1984).

The primary nonforested wetland area in the bay system consists of freshwater and brackish marshes in the Apalachicola delta just above East Bay. Another well-developed brackish-water marsh occurs on the northeast section of St. Vincent Island. Estimates of marsh productivity is a net production of 37,714 mt C/yr (41,561 tons C/yr) in the Apalachicola estuary (East Bay, Apalachicola

Bay, St. Vincent Sound) and 46,905 mt C/yr (51,689 tons C/yr) in the entire bay system (Livingston, 1984c).

Phytoplankton productivity is an important source of organic matter in the Apalachicola estuary (R.L. Iverson, in Livingston, 1984c). The phytoplankton productivity from the bay system approximates 233,284 mt C/year (257,079 tons C/yr); for the immediate estuary (East Bay, Apalachicola Bay) this figure is 103,080 mt C/yr (113,594 tons C/yr). When compared to production values in other estuaries of the region, the phytoplankton productivity and chlorophyll a levels in the Apalachicola estuary are relatively high (Livingston, 1984c).

Estuarine and marine seagrass beds undergo regular seasonal cycles of productivity and standing crop. Based on productivity figures and seagrass distribution, the grassbeds in the East Bay-Apalachicola Bay area produce 8,953 mt C/yr (9,866 tons C/yr). Grassbed production in the remaining portions of the Apalachicola Bay system approximates 18,260 mt C/yr (20,122 tons C/yr). Total production for the entire system is 27,213 mt C/yr (29,989 tons C/yr) (Livingston, 1984c).

The seasonal abundance and spatial distribution of nutrients and detritus in the Apalachicola Bay system result from a combination of forces, some of which are quite localized and specific in nature. The seasonal cycle of nutrient-detritus flux in the Apalachicola estuary has been well established (Livingston et al., 1976a; Livingston and Loucks, 1978). During winter and spring periods of high river flow, dissolved nutrients and particulate organic matter are washed into the estuary. The influx is concurrent with salinity reductions. Peak levels of leaf matter are present during these periods. In the spring, as river flow diminishes, temperature increases, the water becomes clearer, and the spring phytoplankton blooms occur. As nutrients, principally phosphorus, become limiting during summer/fall months, phytoplankton productivity becomes dependent on wind-mixed transfers of nutrients from the sediments into the water column. During the summer and early fall, local rainfall enhances nutrient enrichment. At this time, benthic macrophytes begin to die off. The peak levels of marcophyte organic debris and microaggregates from the marshes occur during the fall as river flow and rainfall are minimal. By late fall (November), temperature drops and salinity coincidentally increases to an annual maximum throughout the estuary. By winter, temperature is low as river flow once again rises (Livingston, 1984c).

Even though the input from various sources is variable in terms of magnitude over time, the input of particulate organic matter to the estuary from all sources is fairly constant. Thus, there is a generally continuous influx of dissolved and particulate organic and inorganic matter to the estuary throughout the year (Livingston, 1984c).

The diverse zooplankton represent an important link between the phytoplankton and higher levels of the estuarine food webs. Almost every major group of organisms is represented in the zooplankton, either as larvae or as adults; great variety is also evident in the relatively extensive size range of individuals. Zooplankton are among the least known assemblages in the Apalachicola estuary. Net zooplankton are composed largely of holoplankton (plankton for entire life cycle; about 90%), while meroplankton (temporary plankton) constitute less than 10% of the total (Edmisten, 1979). The holoplankton are composed mainly of copepods, cladocerans, larvaceans, and chaetognaths. Decapod larvae throughout the estuary are primarily crab zoeae; other zooplankton include polychaete larvae, ostracods, amphipods, isopods, mysids, echinoderms, ctenophores, and coelenterates.

Peaks of zooplankton biomass tend to be associated in some way with phytoplankton peaks, especially in Apalachicola Bay and coastal areas (Livingston, 1984c).

Planktonic fish larvae, derived from either demersal or planktonic eggs, are common among various marine teleost species. The relatively high numbers of ichthyoplankton in the Apalachicola estuary indicate the importance of this system as a nursery for fishes. The most abundant planktonic form is the bay anchovy (*Anchoa mitchilli*); other relatively abundant larvae include silversides (Atherinidae), skilletfish (*Gobiesox strumosus*), gobies (*Gobiosoma* spp.), and various warm-season spawners (Blanchet, 1978). Winter to early spring types are dominated by Atlantic croaker (*Micropogonias undulatus*), spot (*Leiostomus xanthurus*), and Gulf menhaden (*Brevoortia patronus*). Various other sciaenid larvae are taken, including red drum (*Sciaenops ocellatus*), and southern kingfish (*Menticirrhus americanus*).

Because considerable amounts of detrital matter are usually swept into the estuary by the Apalachicola River during winter-spring periods, the organic litter forms an important habitat for various macroinvertebrates. Litter fauna is dominated by isopods, amphipods, and decapods, which utilize particulate matter and litter-associated microbes for food and/or shelter (Livingston, 1976b, 1977a, 1978). Most dominant infaunal populations reach peaks of numerical abundance during late winter and spring periods of low salinity and increasing temperature. Most such species are euryhaline and eurythermal.

Oysters represent an important part of the biota of the Apalachicola estuary. Ingle and Dawson (1951, 1952) noted that the spawning season is one of the longest in the United States (April through November). Ingle and Dawson (1952) found that oyster growth in Apalachicola Bay is the fastest in the United States and is continuous throughout the year because of the relatively high year-round temperatures. Rapid oyster growth due to favorable environmental conditions accounts for the fact that over 90% of Florida's oysters (8%-10% nationally) come from the Apalachicola estuary. Whitfield and Beaumariage (1977) estimate that about 40% of Apalachicola Bay is suitable for growing oysters but that the substrate type is a major limiting factor (oysters need a hard surface for settling on).

Salinity is the most important limiting factor for oyster populations, but it has been hypothesized that such influence is indirect in that low salinity limits predation by excluding important species such as rock shell (*Thais haemastoma*) and stone crab (*Menippe mercenaria*). During periods of high salinity, oyster predation is enhanced and can be considerable. Temperatures also effects oysters, during warmer months, extensive oyster mortality in the Apalachicola estuary has been attributed to infestation by the pathogen *Perkinsus marinus* (formerly called *Dermocyctidium marinum*) (Menzel, 1966). Young oysters are unaffected by this disease, although up to 50% of adult oysters may be killed annually. The relatively long period of high water temperature in the Gulf estuaries contributes to such mortality.

In the Apalachicola Bay system, the nekton comprise the bulk of the sport and commercial fisheries and are among the more conspicuous biological components of the estuary. Various organisms appearing in the estuary may not be estuarine dependent throughout their life histories. Many such organisms are migratory;

such as the anadromous species consisting of sturgeon (Acipenser oxyrhynchus), Alabama shad (Alosa alabamae), striped bass (Morone saxatilis), and skipjack herring (Alosa chrysochloris) (Yerger, 1977). Other species, such as the Atlantic needlefish (Strongylura marina) may be diadromous. Catadromous species include the American eel (Anguilla rostrata), hogchoker (Trinectes maculatus), and mountain mullet (Agonostomus monitcola). Various other freshwater species and some marine forms, such as striped mullet (Mugil cephalus) and the southern flounder (Paralichthys lethostigma), occur in both the river and estuary although they do not make true migrations.

The estuarine dominants such as sciaenid fishes, penaeid shrimp, and blue crabs have annual migrations during which the adults spawn offshore, the larval and juvenile stages move into the estuary, and finally the subadults return to the open Gulf to spawn as adults. Oesterling and Evink (1977) studied migratory habits of blue crabs along the Gulf coast of Florida and found Apalachicola Bay to be the primary spawning ground for the species along the Florida west coast.

The spatial distributions of nektonic fishes and invertebrates in the Apalachicola estuary tend to be associated with freshwater runoff into the system. Relative dominance at a given location varies according to salinity gradients and habitat type. Regular seasonal changes in distributions are evident for most of the dominant nektonic species. While there is a general pattern of concentration of the dominant epibenthic fishes and invertebrates in areas that receive direct input of freshwater runoff from upland areas, it is simplistic to assume that runoff per se is the primary factor that influences the temporal and spatial aspects of the distribution of such organisms in the estuary. There are, in fact, a complex of species-specific limiting factors that are associated with the trophic organization of the bay system (Livingston, 1984c).

TROPHIC RELATIONSHIPS AND FOOD-WEB STRUCTURE

Community structure is determined in part by predator-prey interactions, especially among dominant estuarine populations. Comprehensive studies of the feeding habitat of dominant fishes (Sheridan, 1978; Sheridan and Livingston, 1979) and blue crabs (Laughlin, 1979) have been carried out in Apalachicola Bay. In the bay, the dominant pelagic anchovies feed primarily on calanoid copepods throughout their lives; and larger fish (SL 40-69 mm) eat mysids, insect and juvenile fishes. A seasonal progression of food item consumption follows trends of available prey species.

Although the distinctive nutrient sources for the estuary have been identified, the rate functions of energy movement through the system are little understood. The periodic inputs of nutrients and detritus into the estuary are transformed into biological matter. Such integrative processes continuously smooth out the episodic nature of energy transfer from upland systems. The planktonic and detrital pathways come together at the sediment level through repackaging of fecal material and the activity of the microorganisms. The microbes transform dissolved nutrients into available particulate matter. The sediment organic matrix and particulate organic matter (POM) form the basis of the benthic (detrital) food webs. The grazing of detritus and its microbial populations enhances nutrient quality for subsequent mircobial development by stimulating further microbial productivity and enhancing the nitrogen and phosphorus content of the POM. Physical disturbance, through wind and tidal action and active predation and biological activity, is one of the reasons why the Apalachicola estuary is such a productive system (Livingston, 1984c).

Benthic macroinvertebrates occupy an important trophic link between the primary producers (and microbes) and the upper trophic levels of the estuary. Of the ten numerically dominant infaunal species (representing over 83% of the total number), five are detrital feeders, four are deposit feeders (surface and subsurface), and one is a filter feeder. Of the entire faunal assemblage, there are fifteen omnivore/carnivore types, seven subsurface deposit feeders, eleven surface deposit feeders, twelve (generalized) deposit feeders, twelve (generalized) deposit feeders, and seven filter feeders. There are high numbers of the various filter-feeding mollusks such as Rangia cuneata and Crassostrea virginica (Livingston, 1984c).

An overwhelming majority of the estuarine nekton is omnivorous at some life-history stage, and detritus forms an important component of stomach contents at any given time (Sheridan 1978; Sheridan and Livingston 1979; Livingston, 1982b). Of the seven dominant macroinvertebrates, representing over 90% of the trawl-susceptible catch, five (Penaeus setiferus, Palaemonetes pugio, Callinectes sapidus, Penaeus aztecus and Lolliguncula brevis) are omnivore/carnivore types. While the nutritional importance of the detritus remains in doubt, omnivory appears to be an important characteristic of the predominant feeding patterns at intermediate levels of the estuarine food webs.

Top predators, feeding largely on decapod crustaceans and fishes include spotted seatrout (Cynoscion nebulosus), flatfishes (Paralichtys spp.), adult silver perch (Bairdiella chrysoura), searobins (Prionotus spp.), and various shark types.

The seasonal succession of habitat change, energy distribution, species-specific recruitment patterns, predator-prey relationships, and resulting food web configurations contribute to the biological organization of the estuary. Infaunal macroinvertebrates reach maximum abundance from November through March, although species richness is highest in May. As indicated previously, phytoplankton and zooplankton are abundant during spring months and summer periods. Fish abundance peaks during winter and early spring although fish and invertebrate species richness indices reach their highest level in October. Epibenthic invertebrate abundance, on the other hand, is high during August when penaeid shrimp and blue crabs are prevalent. In general, the dominant fish species, while overlapping in abundance to some degree, tend to predominate during different time of the year; high croaker and spot abundance occurs in winter and early spring, sand seatrout in summer,and anchovies in the fall and early winter. Water column feeders such as anchovies are linked to plankton outburst and predation pressure from species such as sand seatrout. Benthic feeders occur primarily during periods of detritus/macroinvertebrate abundance. Croakers and spot feed largely on polychaetes, while blue crabs concentrate on bivalves. Directly or indirectly, the dominant macroinvertebrate and fish species take advantage of the detritus that is brought into the estuary by the river. The combination of low salinity, high POM, and low predation pressure contributes to the observed high relative abundance of these species (Livingston, 1984c).

PREDATOR-PREY INTERACTIONS AND COMMUNITY RESPONSE

Although productivity trends and habitat characteristics are important factors in the development and control of food web and community structure, biological features such as predator-prey relationships and competition for resources can be extremely important in affecting the biological organization of the estuary. Predation within aquatic associations can lead to changes in relative abundance, species diversity, and other important community indices.

Inverse correlations between predator and prey population exist in the Apalachicola estuary (Sheridan and Livingston, 1983). Macroinfaunal abundance often declines precipitously during periods of peak abundance of the chief sciaenid predators (Mahoney and Livingston, 1982). This suggests that fishes have direct influence on the infaunal assemblages through predation. In grassbed areas, however, infaunal biomass is not affected because larger species (burrowing deeper in the sediments) are not influenced by such predation. Also, recent experiments indicate that macroinvertebrate assemblages in East Bay remain largely unaffected by predation pressure from fishes in the late winter and spring, and by motile invertebrates (penaeid shrimp, blue crabs) in the summer/fall (Mahoney and Livingston, 1982; Livingston unpubl.). Thus, predation does not appear to play a decisive role in the regulation of prey density or macroinvertebrate community structure in oligohaline portions of the estuary during periods of peak predation pressure.

Recent experiments in polyhaline portions of the bay system (Livingston et al., 1983) indicate that salinity could be a factor in the influence of predation on benthic infaunal associations. Preliminary results indicate that predation in polyhaline areas of high macroinvertebrate diversity and low dominance may affect infaunal macroinvertebrate community structure. The influence of salinity on species diversity and relative dominance could be a factor in the relative influence of predation pressure on dominant populations in various portions of the estuary. In areas of low dominance, the influence of predation may be enhanced relative to oligohaline areas where dominance is naturally high. In any case, few generalizations of predation effects can be made without due consideration to local habitat conditions (Livingston, 1984c).

LONG-TERM ECOLOGICAL RELATIONSHIPS

Although diurnal and seasonal changes in population and community structure in the estuary are relatively well documented (Livingston, 1976b, 1977a, 1978; Livingston et al., 1974, 1977), the long-term biological relationships, measured in decades, are still under consideration (Livingston unpublished data). Seasonal changes in important physical and chemical factors are relatively stable in terms of timing; however, there is considerable annual or year-to-year variations of such factors. The coupling between climatological features such as river flow and long-term changes in the commercial catches of oysters, shrimp, and crabs (Meeter et al., 1979) is often complicated by socioeconomic influences on such data (Whitfield and Beaumariage, 1977).

The specific short-term distribution of a given species is often associated with complex habitat variables and the availability of food. At the same time, long-term changes in a given population in the estuary may be influenced by climatological cycles. Timing of the succesion of climatological changes is important. For example a specific temperature has entirely different meanings to a given species in the spring and in the fall (Livingston, 1984c).

Temporal variability is extremely complex since, at any given instant, a natural system represents a composite of different sequences of varying periods superimposed over one another as the result of an almost infinite number of cause-and-effect reactions. Determining causality is difficult because these overlapping cycles may differ along habitat gradients and at different levels of biological organization (Livingston, 1984c).

Annual variability among dominant fish populations in the Apalachicola estuary are considerable. Each species follows a distinct, long-term pattern of abundance; no single aspect of the physical environment is apparent as the controlling factor of the long-term changes. It is clear that factors other than temperature and salinity are important in the control of long-term fluctuations of these populations. Although generalized temperature and salinity preferences are well established for various estuarine species, most such organisms have a relatively wide tolerance for these factors. Tolerance of this kind could explain the lack of importance of these factors in the determination of long-term population variability (Livingston, 1984c).

Various independent ecological factors operate to determine the temporal distribution of the dominant estuarine organisms. Biological functions, such as adaptive response to the physical and trophic environment, determine distributional patterns, thereby allowing a somewhat orderly temporal succession of dominant forms within certain broad trophic spectra. Patterns of reproduction of various dominant estuarine species have evolved in such a way as to permit long-term partitioning of the estuarine environment. Superimposed on these patterns of response are varying levels of resource division based on vertical and horizontal distribution of the component species. Various microhabitat phenomena such as salinity, bottom type, currents, and the availability of detritus and food are important. Thus, no single parameter prevails in the determination of the community structure of the estuary, which itself undergoes predictable seasonal changes as part of a physically forced system (Livingston, 1984c).

Although there are appreciable short-term fluctuations in the numbers of individuals of different populations, the system maintains a temporal constancy which, according to a traditional view of such phenomena, could be termed stability. This does not mean that the system is not in a constantly transient state. On the contrary, through natural and unnatural mechanisms such as habitat alteration and destruction, hurricanes, cold winters, and periodic flooding, the various population equilibria continuously shift. Each population fluctuates around a specific point of equilibrium, and the fluctuations reflect the adaptive response to the specific aspects of the estuarine environment (Livingston, 1984c).

The Apalachicola estuary is physically unstable in time but is characterized by epibenthic populations which maintain relatively stable temporal interspecific relationships. The dominant fishes and invertebrates are temporarily partitioned in time. Particular groups of fishes tend to co-occur. Generally, three main clusters are arranged around the top dominants, Anchoa mitchilli, Micropogonias undulatus, and Cynoscion arenarius. The anchovy group is abundant during the fall. The Micropogonias group predominates during winter and early spring periods, and the Cynoscion group prevails during the summer and early fall (Livingston, 1984c).

THE ESTUARY AS A RESOURCE

Fisheries

The commercial fisheries of the Apalachicola Bay system are diverse and substantial. According to the summaries of commercial marine landings in Franklin County (Florida Department of Natural Resources, 1952-1976) and analyses of

projections of commercial populations, there is considerable annual variation of such landings over the period of observation (1952-1976) (Cato and Prochaska, 1977). Shrimp, together with oysters and blue crabs, provide over 80% of the annual catch by weight. Black mullet and grouper contribute almost 14% of the remaining catch. Whiting, menhaden, flounder, red snapper, and spotted seatrout all contribute to the overall landings. In terms of total value, shrimp (53.9%), oysters (33%), and blue crabs (5.1%) constitute the backbone of the commercial fishery value in Franklin County, which itself accounts for over 90% of Florida's oyster landings and the third highest catch of shrimp statewide.

The oyster fishery in the Apalachicola estuary has historical significance (Swift, 1896; Ruge, 1897; Danglade, 1917). Many of the historic observations were similar to today's in that floods and droughts have an important impact on the viability of individual oyster bars. The present distribution of oyster bars does not differ substantially from that depicted on maps produced during the early part of this century (Whitfield and Beaumariage, 1977). Commercially valuable oyster bars currently cover only half the area estimated to be available at the turn of the century. Shell planting with "cultch" or shucked shells has proven to be a successful management technique for encouraging oyster bar development (Whitfield, 1973). Approximately 40% of the Apalachicola Bay area is suitable for growing oysters if cultched in an appropriate manner (Whitfield and Beaumariage, 1977). The actual and potential productivity has been attributed to the unique geographical and physical attributes of the largely unpolluted Apalachicola drainage system. More sanitary (safe) harvesting waters for oysters exist in the Apalachicola estuary than in any other Florida estuary. Considerable support exists for this industry as a regional and statewide natural resource. This fact, added to recent information that the Apalachicola Bay system appears to be a major spawning or source area for the entire Florida Gulf blue crab fishery (Oesterling and Evink, 1977), has stimulated various research investigations concerning future fishery potential.

The overall Apalachicola fishery resource has grown substantially over the past decade. During the period from 1977 to 1981, all previous oyster production records were broken on an annual basis (Joyce, 1983). The record landings were due largely to an increase in the fishing effort (Prochaska and Mulkey, 1983), although newly instituted programs of summer oystering (1977) and an oyster relay program (Futch, 1983) have added to the annual crop. Although oyster production has increased to 41% of the total Franklin County landings, the relative value of the oyster crop has declined to 36%, partly as a result of increased county shrimp landings and considerable increases in shrimp prices (Prochaska and Mulkey, 1983). Blue crabs constitute about 5% of the total value of the commmercial fishery in Franklin County. Of the commercial finfish catch, striped mullet (Mugil cephalus) is the most important. Grouper, menhaden, and whiting are also taken, although the commercial finfish industry has declined in recent years (Livingston, 1983c).

Sport fishing in the Apalachicola Bay system remains largely undeveloped, although the potential exists for a highly productive industry. Sport fisheries associated with the estuary include spotted seatrout (Cynoscion nebulosus), red drum (Sciaenops ocellatus), tarpon (Megalops atlanticus), sheepshead (Archosargus probatochephlus), black drum (Pogonias cromis) and flounder (Paralichthys spp.). Fishes taken offshore include various species of sharks, cobia (Rachycentron canadum), bluefish (Pomatomus saltatrix), red snapper (Lutjanus campechanus), and different species of grouper. The development of artificial offshore reefs in the region could add considerably to the continued development of sport fisheries in the area (Livingston, 1984c).

SOCIOECONOMIC FACTORS

The Apalachicola valley depends to a considerable degree on a rather narrow economic base. The natural features of the river and bay system continue to attract new residents, especially in the coastal areas. The Apalachicola River/estuary/wetlands system contributes an important part of the regional economy and culture. Franklin County, which surrounds the Apalachicola Bay system, has a relatively limited scope of employment with primary dependence on products from the aquatic resource base, timber production, and tourist expenditures (Colberg et al., 1968). Commercial fisheries alone provide jobs for over 65% of the Franklin County work force. Fishing is an "export" industry for Franklin County because practically all sales are outside the region (Prochaska and Mulkey, 1983). Export sales trigger a chain reaction throughout the local economy because direct and indirect purchases generate income, and so-called "multiplier" effect. Recent estimates indicate that the forestry and fisheries "export" values are even more important than previous studies indicated since practically all such production is sold outside the region. The total current value of fisheries in the drainage system and associated coastal areas exceeds $23 million. Colberg et al. (1968) projected a value of $34.2 million for commercial fishing and tourism by the year 2000 if water quality and natural productivity are maintained. Value added as a "multiplier" effect would increase this estimate to almost $67 million. Thus, the as yet undiminished natural resources in the Apalachicola valley provide an important economic base for the local area, and such natural industries have a direct influence on the region through export and respending. Rockwood et al. (1973) and Rockwood and Leitman (1977) provided an in-depth analysis of the socioeconomic basis of the Apalachicola oyster industry. The potential for oyster production has yet to be reached; greater production will be necessary if the relatively low per-capita income is to be increased and more employment is to be provided for young people in the area. In terms of general determinants of regional growth, Franklin County is rich in natural resources on which it is almost entirely dependent.

PUBLIC LAND INVESTMENT

Public and private parks, designed to conserve or preserve areas in the Apalachicola Valley, are scattered throughout the area. The Torreya State Park includes unique habitats and plant species such as the endangered Florida Torreya cedar and ravine habitats. The Apalachicola National Forest and State wildlife management areas allow recreational and hunting opportunities. A State-owned park on St. George Island permits public beach-front recreation, and St. Vincent Island National Wildlife Refuge is used for wildlife observation, fishing, and controlled hunting activities.

Considerable effort has been expended in the preservation of barrier islands bordering the Apalachicola estuary. Based on information concerning the importance of the islands to the bay productivity (Livingston et al., 1976), portions of the eastern end of St. George Island were added to the existing state park. In 1977, the State of Florida purchased Little St. George Island (Cape St. George Reserve). Approximately 526 ha (1,300 acres) of undeveloped land on Dog Island were purchased by the Nature Conservancy in 1982 for the implementation of an island conservation program. In addition, the Trust for Public Land purchased that portion of St. George Island known as Unit 4 which borders the highly productive oyster beds of East Hole. This land was recently repurchased by State

agencies as part of the Conservation and Recreation Lands (CARL) program (formerly the Environmentally Endangered Lands (EEL) program). The balance of St. George Island is still in private ownership. Major portions of the holdings on western portions of this island are already restricted by planning regulations to 1 unit/acre. Thus, much of the barrier island system is currently under public ownership or within the jurisdiction of the comprehensive plan of Franklin County.

Apalachicola River and Bay National Estuarine Research Reserve

The Apalachicola National Estuarine Research Reserve (formerly Sanctuary) was established in September 1979 as a cooperative effort between Local, State, and Federal governments under the Federal Coastal Zone Environmental Land Management of the Florida Department of Natural Resources. The establishment of the Reserve was primarily for research and educational purposes, although multiple use of the Reserve is encouraged. To the extent such usage is compatible with the primary Reserve purpose. These uses generally include activities such as low intensity recreation, fishing, hunting, and wildlife observation and other aesthetic activities (Miley, 1985).

The Apalachicola Reserve is the largest of 15 existing estuarine reserves and represents the Louisiana Biographic Region. The Reserve encompasses 78,150 ha (193,118 acres); most (54906 ha or 135,680 acres) are submerged lands. The Reserve includes Apalachicola Bay, portions of the Apalachicola River floodplain and portions of the adjacent barrier islands (Miley, 1985).

The Florida Department of Natural Resources (FL DNR) has the management authority for the Reserve with headquarters and a Reserve manager in the City of Apalachicola. The Apalachicola Reserve Management Committee is composed of 11 persons who are primarily responsible for determining the policies for management of the Reserve (Miley, 1985).

Conservation and Recreational Lands (CARL) Environmentally Endangered Lands (EEL) Progra

In 1972, the Florida Legislature passed the "Land Conservation Act" which authorized the State to purchase environmentally endangered lands (EEL). This action, coupled with an ever-growing desire to protect the area, resulted in the authorization of the series of land purchases in the Apalachicola River basin (FL G&F, 1982c). The Program is now under the Conservation and Recreational Lands (CARL) Program created by the Legislature in 1979.

On October 2, 1974, the Governor and Cabinet authorized under the EEL Program the first phase purchase of a large tract of land in the lower Apalachicola River basin, in Franklin and Gulf counties. Since then, 11,380 ha (28,122 a) of marsh and floodplain forest have been acquired and incorporated into the lower Apalachicola River CARL tract. These lands provide for the protection and preservation of the highly productive Apalachicola River and Bay estuarine system. Some of the purchased lands are considered buffer areas necessary to protect the valuable marshes, and natural vegetation essential to the bay's continued productivity. The current boundaries of the CARL lands begin at a point about 1.6 km (1 mi) north of the City of Apalachicola and extend approximately 19 river miles northward to the vicinity of the Brickyard Cutoff at river mile 20.7. Along the corridor the lands vary in width with a maximum of almost 9.6 km (6 mi) across the southern portion. According to Florida statutes, land below the "ordinary high water line" of the river is already owned by the State (FL G&F, 1982c).

The Florida Department of Natural Resources has land ownership functions and has entered into a resource management agreement with the Florida Game and Fresh Water Fish Commission (lead agency), the Division of Forestry of the Department of Agriculture and Consumer Services (cooperating Agency), and the Division of Archives, History and Records Management of the Department of State (cooperating agency). The lead managing agency has responsibility for coordination of management activities on the CARL tract (FL G&F, 1982c).

Save Our Rivers Program

The Save Our Rivers Program was established by the Florida Legislature in 1981 creating the Water Management Lands Trust Fund (1985 name change to Florida Resource Rivers Act) to acquire lands needed for water management and water supply, and for the conservation and protection of water resources. The authority was given to the five water management districts of the State.

The Northwest Florida Water Management District (NWFWMD) oversees lands and waters within the Apalachicola River basin. Currently the NWFWMD has purchased 14,568 ha (36,000 acres) of floodplains adjacent to and north of the Apalachicola Reserve holdings (Dawdy, 1985; NWFWMD, 1982; JLMC, 1981, 1985).

Outstanding Florida Water

The entire Apalachicola River has been designated as an Outstanding Florida Water (OFW). Generally, the State cannot issue permits for direct pollutant discharges that would lower ambient water quality or for indirect discharges which would significantly degrade OFW's (FL DER, 1984b).

Florida Aquatic Preserve

Apalachicola Bay has also been designated a Florida Aquatic Preserve. The State of Florida Aquatic Preserve Act (Chap. 358 F.S. 258-35-258.46) sets aside forever aquatic preserves or sanctuaries for the benefit of future generations " ... State-owned submerged lands... which have exceptional biological, aesthetic, and scientific value." Primary purpose of the Aquatic Preserve designation is to maintain the high quality of the area by restricting dredging and filling to a minimum or in the best public interest, prohibition of drilling for gas or oil or wastes effluent discharges incompatible with the accomplishment of the Aquatic Preserve designation (Brim, 1985).

Florida Area of Critical Concern

Further, Apalachicola Bay is a State of Florida Area of Critical Concern. Areas of Critical State Concern are authorized under the Florida Environmental Land and Water Management Act (Chap. 380 F.S. 380.012-380.12). Reasons for the designation include: "... an area containing, or having a significant impact, upon, environmental, or natural resources of regional or statewide importance, ...the uncontrolled private or public development of which would cause substantial deterioration of such resources.". The primary purpose of an Area of Critical Concern designation is to insure a water management system that will reverse the deterioration of water quality and provide optimum utilization of limited water resources, facilitate orderly and well-planned development, and protect the health, welfare, safety, and quality of life of the residents of the State of Florida (Brim, 1985).

Gulf Coastal Plain Biosphere Reserve

In 1983, the United Nations Educational, Scientific and Cultural Organization (UNESCO) designated the lower Apalachicola River basin as a unit of the central Gulf Coastal Plain Biosphere Reserve. The designation reflects international recognition of the basin's scientific and educational value. It also represents a responsibility to use the area to develop the knowledge and practical skills for sustainable conservation of a representative example of the world's major ecosystems, and to share new insights with scientists, resource managers and policy makers, both domestically and internationally (Miley, 1985; FL DNR, 1983).

In summary, there has been a continuous and quite successful effort over the past decade to purchase and place in public stewardship those portions of the Apalachicola estuarine system which have been identified as important for maintaining the high productivity of the area.

EXISTING AND PROJECTED IMPACT BY MAN

Environmental protection has been a dominant trend for the Apalachicola River and estuary since the mid-1970's. Public and governmental awareness of the high environmental resource values of the Apalachicola River/estuary/wetlands ecosystem began to increase rapidly in the early and mid-1970's. This was possibly stimulated by proposals for U.S. Army Corps of Engineers locks and dams on the river; attempted conversion of more than 10,000 acres of lower river floodplain wetlands to agricultural use (M K Ranches); widespread clearcutting, drainage, and establishment of pine mono-culture in Tates Hell Swamp (a major drainage area to East Bay); and proposals for extensive residential and commercial development on St. George Island (Clewell, 1977; Livingston and Joyce, 1977).

This increased environmental awareness led to a number of conservation measures or special-status designations for major components of the ecosystem.

In addition to the preceding, an action which pre-dated the present era of environmental concern was the Federal acquisition of St. Vincent Island to establish St. Vincent National Wildlife Refuge.

Despite the environmental protection trend, other trends continue to threaten fish and wildlife resources. Among these are recently accelerated commercial and residential development on St. George Island, and clearcut forestry practices. One of the most pronounced fish and wildlife threatening activities on the Apalachicola River and Bay system has been with the operation and maintenance activities of the Federal navigation channels in the Apalachicola River (Clewell, 1977; Livingston and Joyce, 1977; U.S. FWS, 1986c).

The construction and maintenance activities have blocked fish movements to upstream habitats by dam construction, converted high-quality forested floodplain wetlands habitat to low-quality xeric areas, reduced river oxbow habitat, degraded former natural bank zone habitat by spoil disposal, removed biologically productive rock shoal habitat, and possibly diminished water depth and quantity in floodplain streams due to entrenchment of the river and disposal-induced sedimentation in sloughs (U.S. FWS, 1986c).

To address these concerns as well as plan for future activities, extensive coordination has taken place among the U.S. Corps of Engineers (COE) and State and Federal environmental agencies since the early 1970's. The 1983 Memorandum of Agreement (MOA) between the COE and the States of Alabama, Georgia and Florida also precipitated a significant coordination effort for all involved agencies. Coordination efforts have included (1) the creation of an Interim Coordinating Committee (ICC) to administer MOA activities; (2) interagency field investigations of maintenance dredging disposal sites on the entire Apalachicola River with resultant follow-up meetings; (3) numerous interagency planning meetings. The interagency planning sessions were most productive in their output which included: preliminary documents to the Draft Navigation Maintenance (DNMP); documents relating to the DNMP formulation which consisted of the COE's "ACF Water Assessment", "ACF Environmental Evaluation Methodology", "ACF Interim Drought Management Plan". "ACF Environmental Impact Overview", and "Apalachicola River Disposal Site Evaluation Studies"; Florida DER's "Apalachicola River Dredged Material Disposal Plan", and the FL G&F's "Fishery Study, Apalachicola River Maintenance Dredging Disposal Site Evaluation Program"; and (4) field effort for the recovery of striped bass and sturgeon (U.S. FWS, 1986c).

Throughout the Apalachicola River and Bay system increased development can be expected. Development pressure, although large portions of the lower river and bay are protected through legal designations, require stricted control and enforcement of land uses adjacent to the system to insure maintenance of the high quality fish and wildlife habitats and water resources. The river is presently not considered a major water supply source, and therefore reduction of the water budget from this activity is not a concern. Commercial navigation is and will be a major concern as the usage of the river is expected to increase. Maintenance and operations of navigation channels will need to be reconciled with the stewardship of the valuable fish and wildlife resources found in the basin. Through the extensive coordination and cooperation that is ongoing between the involved State and Federal agencies, these issues can be resolved so that all interests are benefitted (U.S. FWS, 1986c).

Water Quality/Toxic Substances

Numerous studies (Winger, 1981; Elder, 1984; Watts, 1984; Bank, 1984; Winger, 1985; Ray, 1986; Livingston, Thompson and Meeter, 1978) have been conducted on the Apalachicola and Chipola River systems concerning contamination by heavy metals and/or organochlorine pesticides. Recent sediment sampling from the dredged channels of the Intracoastal Waterway channel in the bay shows unnatural levels of cadmium and zinc probably from anthropogenic sources. However, Ryan (1986) found that the high metal levels found in the basin are of natural origin. The basin has sediments that are very high in alumino-silicate minerals; these sediments have naturally occurring metals bound in their crystalling structure.

The entire bay system from Alligator Harbor thru St. George Sound, Apalachicola Bay, East Bay and tributaries, St. Vincent Sound, and Indian Lagoon are Class II waters[1] with the exception of a two-mile radius near Apalachicola and the area

1. See Appendix II for State of Florida Surface Water Quality Criteria.

north of the Eastpoint Breakwater. This area has been closed to shellfishing for years due to pollution from the City of Apalachicola and runoff from Eastpoint. Class II waters, those used for shellfish propagation or harvesting, include the majority of the brackish water areas in the estuary. These standards are more stringent concerning bacteriological quality than any class due to the fact that shellfish, oysters and clams that are consumed uncooked by man can concentrate pathogens in quantities significantly higher than the surrounding waters. The Florida Department of Natural Resources (DNR) maintains a lab in Apalachicola and conducts surveys to determine water quality in shellfish waters. All Class II waters are additionally classified by DNR as approved, conditionally approved, or prohibited based upon these surveys. As conditions change, areas are closed or opened based on bacterial surveys and major rainfall events which increase bacterial levels due to runoff.

Municipal Development

Municipal development in Florida is concentrated along the coast. The Big Bend region, which includes the Apalachicola Bay system, remains one of the last relatively undeveloped coastal areas in Florida. In Franklin County, urbanization is restricted to the cities of Apalachicola (approximately 3,000 people) and Carrabelle (approximately 1,000 people). The Apalachicola sewage treatment plant was originally designed as a state-of-the-art facility, however, faulty construction has caused severe problems (Lewis, 1987). There are also nutrient problems at the Carrabelle sewage treatment plant (Hand and Jackman, 1984). However, nutrient, phytoplankton, and dissolved oxygen data indicate no discernible tendency for cultural eutrophication in the estuary (Livingston unpubl.).

Most of the construction activity in the Apalachicola Bay system has occurred in Apalachicola and East Point and on St. George Island. While there is considerable pressure for construction on the island, population density is still relatively low.

Coastal development is often accompanied by the loss of natural vegetation, increased levels of solid waste, and enhanced effluent discharge. These activities often lead to increased runoff, erosion, physical alterations, changes in water circulation, deposition of sediments, and introduction of various pollutants into the river-bay system. Such changes can have an adverse effect on the natural resources of the area. According to Bell and Canterbery (1974, 1975), "The major cause of closing of commercial shellfish areas is bacterial pollution at sublethal contamination levels." Closing of Louisiana's shellfish beds went from 5,900 acres in 1965 to 198,812 acres in 1971, a 3200% increase. In Florida considerable areas of shellfish grounds are closed each year because of pollution. Of over 2 million acres of available shellfish areas in Florida, only 22% are approved for harvesting; 13% are prohibited, 5% are conditionally approved, and about 60% are unclassified.

The national figures show over 3 million acres of clam and oyster beds closed, at a loss of over $38.4 million (Bell and Canterbery, 1975). Septic tank effluents, sewage waters, and municipal and industrial runoff account for most of these problems. There have been a number of incidents in which oystering in the bay has been closed because of high coliform counts (Livingston et al., 1978). This problem also causes concern for the commercial fisheries of the area which account for 65% of the Franklin County income (Florida Department of Administration, 1977).

St. George Island forms the gulfward perimeter of Apalachicola Bay and is of critical importance to bay productivity because its orientation determines the distribution of salinity and other water quality features of the estuary. Portions of St. George Island are currently under considerable pressure for municipal development. Based on past experience in Florida and other coastal states, the outlook for St. George Island is to be the center of the growth for Franklin County. On St. George Island, as elsewhere in the drainage area, there is a real need for planned development if the natural resources of the estuary are to be maintained.

Overall, the Apalachicola River and Bay system remains relatively pollution free at this time. It will take imaginative and progressive planning and resource management action if the aquatic resources potential of the Apalachicola estuary is to be preserved and enhanced.

COMPARISON WITH OTHER ESTUARIES

The Apalachicola estuary has been included in a comparison of 14 estuaries on the Atlantic, Gulf of Mexico, and Pacific coasts of the United States * (Nixon, 1983). This study indicated that Apalachicola Bay is a relatively small and shallow estuary, rapidly flushed, with a considerable watershed area when compared to other estuaries in the United States. The cross-sectional area of the Apalachicola estuary ($18.1 \times 10^3\ m^2$) is relatively small compared to most of the other estuaries. Because of the dimensions of the bay and the volume of freshwater input, Nixon (1983) estimates that dissolved and suspended materials are likely to remain in Apalachicola Bay for a shorter time than in many of the other estuaries in the survey. The relatively high level and strong seasonality of the rainfall in the Apalachicola drainage basin would contribute to the high river discharge rates to the estuary. Approximately 62% of the surface area of the estuary has salinities that average less than 15 ppt. Apalachicola Bay stands out, along with Mobile Bay and Northern San Francisco Bay, as a system that responds to river discharge in "a major way" (Nixon, 1983). Because of the physical characteristics and the relatively high annual level of solar radiation, Apalachicola Bay and Kaneohe Bay (Hawaii) are the only estuaries of those surveyed in which the bay bottoms fall within the euphotic zone (Nixon, 1983). This fact, together with the major impact of the river on the estuary, could help to explain the apparently high productivity of the Apalachicola system.

Relatively little of the Apalachicola primary productivity is due to cultural eutrophication from input of nutrients from human wastes. The Apalachicola is the least developed of the estuaries surveyed, with an extremely low population density. The contribution of nutrients from point source discharges to the Apalachicola estuary is extremely low. These data indicate that the Apalachicola estuary remains in a relatively natural state compared to other such systems around the country.

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* Narragansett Bay, Long Island Sound, New York Bay, Raritan Bay, Delaware Bay, Chesapeake Bay, Patuxent Estuary, Potomac Estuary, Pamlico Estuary, Mobile Bay, Barataria Bay, Northern San Francisco Bay, South San Francisco Bay, Kaneohe Bay.

When compared with other estuaries in the Gulf, Apalachicola Bay has a similar or larger zooplankton assemblage in terms of numbers and biomass (Edmisten, 1979). Such numbers are comparable to those taken in various estuaries in the United States (Nixon, 1983). A comparison of ichthyplankton in the other estuaries surveyed (Nixon, 1983) indicated that the bay anchovy (Anchoa mitchilli) as a dominant species is a common characteristic in half the estuaries surveyed (Nixon, 1983). The low numbers of fish eggs in the Apalachicola system, relative to other areas such as Tampa Bay, has been attributed to the relatively low salinities in the Apalachicola estuary (Blanchet, 1978). Attempts to make comparisons between the level of primary production and abundance of organisms at higher trophic levels indicate no direct or simple correlation (Nixon, 1983).

Livingston (1981b), in a comparison of the distribution of various sciaenids in estuaries along the northeast Gulf of Mexico, found that the Apalachicola estuary is extremely productive in terms of fish populations. Prime habitats include the mud flats of East Bay and the mouth of Apalachicola River, and the grass beds in Apalachicola Bay off St. George Island. The unpolluted, highly turbid estuary, with its high plankton productivity and abundant allochtonous detritus, presents an optimal environment for benthic omnivores (such as croaker and spot) and epibenthic carnivores (such as silver perch and sand seatrout).

Compared with other estuaries, the Apalachicola system has relatively low finfish landings, while blue crab landings are moderately high (Nixon, 1983). However, in terms of oyster yield per unit area, the Apalachicola estuary was the second highest of those systems surveyed (Nixon, 1983). Although the connection between fishery yields and primary production remains largely undetermined in a quantitative sense, the importance of the response of individual species to varying sets of environmental conditions probably plays a considerable role in the form and direction of secondary production in any given system.

ANADROMOUS FISH

Anadromous fish species occurring in the ACF system are Gulf of Mexico sturgeon (Acipenser oxyrhynchus desotoi) (a subspecies of the Atlantic sturgeon), Alabama shad (Alosa alabamae), skipjack herring (Alosa chrysochloris), and striped bass (Morone saxatilis).

Alabama shad and skipjack herring are found in fair abundance in the Apalachicola River, Chipola River and Lake Seminole. Skipjack herring seem to be more abundant upstream of Jim Woodruff Lock and Dam (JWLD), especially in the Chattahoochee River. These two species are of very little direct importance to fishermen, however, they are probably important as food fish for carnivores.

Recent studies of sturgeon and striped bass on the Apalachicola River have yielded significant findings regarding the Gulf populations of these species and their habitats. U.S. Fish and Wildlife Service studies on the river from 1975 up to the present have shown that the native Gulf race striped bass lives longer, and is better adapted to these waters than the introduced Atlantic strain. They also found that the cool water habitats such as the springs in the river and spring runs tributary to the river are very important habitats for the striped bass during the summer. These are considered cool water refuges for the bass and

are heavily used when the water temperatures reach 26^{o} C and above. The construction of JWLD prevents the normal migration of striped bass to the numerous springs in Lake Seminole and the Flint River. Their total range has been reduced from 1,018 km (631 mi) to 182 km (112 mi) (Wooley and Crateau, 1985).

Wooley and Crateau (1983) estimated that the population of Gulf race striped bass above 381 mm (15 in, age 3-12) in the upper Apalachicola River numbered 853 in May, 1981. Their tagging program showed that:

1. The majority of the adult population were located in the upper river.
2. Six striped bass (7% of those recaptured) moved through the lock at JWLD. Two of these were captured in the Flint River, one in the Flint River section of Lake Seminole, and three in the Chattahoochee River.
3. The Gulf striped bass is a riverine race with little or no coastal movement.

Comparing the native striped bass with the introduced Atlantic striper, they found:

1. No significant difference in growth between ages 1 and 8.
2. 8% of the Atlantic striped bass were over 7 years of age compared to 29% of the Gulf race.
3. Condition factors averaged significantly higher for the Gulf fish compared to the Atlantic, especially in the summer, although all striped bass larger than 4.5 (10 lb) kg had a lower condition factor during summer.

They also state that prior to completion of JWLD in 1957 and the Dead Lakes Dam in 1962, striped bass were known to inhabit numerous spring areas in the Flint River, Spring Creek, and the Chipola River during the summer months.

After the dams were built, this summer habitat was lost to striped bass in the Apalachicola River system. The remaining thermal refuges for these fish are the spring runs, cool creek mouths and underwater springs in the upper river below JWLD. In addition, the thermal refuges may be significantly affected by projected increases in ground water withdrawal for irrigation purposes which would decrease the base flow of the lower Chattahoochee and Flint Rivers by as much as 30% (Radtke, et al., 1980).

The Fish and Wildlife Service has, for the past few years, attempted to artificially propagate Gulf race striped bass with a goal of restoring the native striped bass population to the ACF system and other Gulf of Mexico river systems. Since 1980, a total of 788,300 striped bass fingerlings taken from ACF broodstock have been stocked back into the system (stocking occurred in 1980, 1982, 1983, 1984, 1986). Although the striped bass sport harvest is small compared to other species taken, it represents an important sport fishery due to the fish's large size and "trophy" value. According to FL G&F spring creel surveys in the upper 7.2 km (4.5 mi) of the river since 1982, there has been a positive trend in striped bass catch since the 1980 stockings (stocking effects are usually seen two years later) except for in 1984. The low 1984 catch may be attributed to a 50% reduction of the number of fish stocked in 1982 than were stocked in 1980.

The striped bass population in the Flint River and Lake Seminole provides a unique trophy fishery that has a potential to produce a new all-tackle world record striped bass. Three line test category world records recognized by the International Game Fish Association (1985) are held by fish caught in the Flint River at Albany (Keefer, 1986).

Natural spawning by striped bass was documented in the Flint River-Lake Seminole system during 1985. The spawning activity appeared to occur between Flint River km 57 and 162, with the bulk of the activity taking place between km 88 and 133. Further, young-of-the year were also found in the Flint River and Lake Seminole, and identified as both Atlantic and Gulf race individuals (Keefer, 1986).

The Gulf subspecies of the Atlantic sturgeon is also found in the Apalachicola River, however the population level is at an all time low. Wooley and Crateau (1985) estimated that only 282 (range: 181-645) sturgeon larger than 450 mm (17.5 in) were in the upper river in 1983. The 1985 population estimate for sturgeon 755 mm (29.5 in) or larger was 96 (range: 74-138). The river supported a commercial and sport sturgeon fishery until about 1970. The 1986 upper river summer population estimate of sturgeon 450 mm (17.5 in) or larger was 60 (range: 37-154). This is 38% below the 1985 estimate. In 1984, the State of Florida issued a regulation prohibiting the taking of sturgeon by commercial or sport fishing means.

The Gulf sturgeon is also under Federal review as a Category 2 species, which comprises taxa for which information now is in possession of the FWS indicates that proposing to list as endangered or threatened is possibly appropriate, but for which conclusive data on biological vulnerability and threat are not currently available to support proposed rules (Federal Register Vol. 50, No. 181, September 18, 1985).

FWS studies found that the Gulf sturgeon spends much more time in fresh water in the Apalachicola River than was originally suspected (up to 7 months of the year). Radio tagged sturgeon spent a major portion of their time in the area below JWLD. This is a strong indication that their historical migration was above the area of the dam. There is little evidence of sturgeon passage through JWLD, or dams on the Flint and Chattahoochee Rivers. Some biologists also believe that the filling and alteration of oxbow lakes was a significant negative impact on sturgeon by elimination of deep, still-water areas for rest and feeding.

The U.S. Army Corps of Engineers (COE), Mobile District, 1978 study on diadromous fish which was included in the "Coordination Report on Navigation Improvement for Apalachicola River Below Jim Woodruff Dam, Florida" found that the general decline in striped bass in the Apalachicola River since the completion of the JWLD would certainly indicate the dam bears at least partial responsibility for diminished population levels. This is also true for sturgeon. The study reported that prior to the JWLD completion in 1957, sturgeon were reported to have migrated 320 km up the ACF system. Closure of the dam caused the sturgeon to congregate below the dam and resulted in the development of a hook and line "snag" fishery in the tailrace in 1962 (Huff, 1975). As a result of these occurrences and diminished commercial catches in recent years, it appears that JWLD has been partially responsible for the decline in the ACF's sturgeon population by restricting it from historical spawning, and feeding areas upstream in the Chattahoochee and Flint Rivers. FWS studies show that sturgeon suffer severe weight losses as they spend the summer months in the JWLD tailrace.

JWLD and Dead Lakes Dam have been the major obstacles to anadromous fish in the ACF system, although other dams below the Fall Line have impeded migration. Wooley and Crateau (1983) observed that only 17% of historic unrestricted in-river range is now available.

The Mobile District COE (1978b) concluded that historically, the ACF system contained 983 km (610 mi) of potential anadromous spawning habitat. Non-federal dams eliminated 364 km (225 mi) of main river channel from use by anadromous fish. JWLD restricted an additional 425 km (264 mi) of riverine habitat from use by anadromous species. The following recommendations were made in the COEs' report.

1. Efforts to enhance the diadromous fishery of the ACF system should be devoted only to the anadromous species.

2. Measures for enhancement should be concentrated on the Gulf sturgeon, Alabama shad, and striped bass.

3. Enhancement measures should not be initiated until after completion of the FWS' anadromous fish study in 1980, at which time adequate data should be available upon which decisions could be made to improve conditions in the ACF system for the Gulf sturgeon, Alabama shad, and striped bass.

4. Agencies responsible for the management of the ACF system's water resources should work together to determine the need for an anadromous fishery and fiscal requirements to expand the existing stocking program to supplement the striped bass fishery.

5. Studies that consider the construction of additional dams for the development of the system's water resources should include evaluation of potential fish passage measures as an important aspect of the overall study.

Sturgeon and Striped Bass Recovery Efforts

The major effort for recovery of the native Gulf striped bass has been by the FWS in a restocking effort and identification of important habitat areas. This has been seriously hampered by lack of available funds and personnel. Restocking is probably the most practical way to restore and maintain both the striped bass or sturgeon, with the present knowledge of the species.

Means of fish passage through dams, especially JWLD should benefit all anadromous fish populations in the system, however, it could have undesirable impacts on sturgeon and striped bass. The main benefits from successful fish passage through JWLD would be access to new feeding areas and cool water refuges in Lake Seminole and lower Flint and Chattahoochee Rivers. Studies would be needed to determine if sturgeon would be able to pass downstream and if desirable conditions exist upstream of JWLD for spawning and feeding of sturgeon and striped bass.

The following are suggested means for mitigation for the negative impacts of JWLD on anadromous fish and needs for enhancement of striped bass and sturgeon populations (U.S. FWS, 1987a).

1. Studies to determine timing and location of Gulf striped bass and sturgeon spawnings in the Apalachicola River. The COE, Mobile District is providing financial support for a 1987 spawning season effort to be conducted by FWS.

2. Continued FWS effort in collecting native broodstock for Gulf striped bass and sturgeon restocking with addition of a spawning and hatching facility for striped and sturgeon. The COE, Mobile

District has provided facilities for equipment storage at JWLD in the past and is also providing financial support for a spawning and hatching facility for the 1987 spawning season.

3. Provide facilities and equipment necessary for tagging and monitoring stocked populations.

4. Determine if a means of successful fish passage could be developed for JWLD and other Federal dams below the Fall Line. This may require a study of the feasibility of locking manipulations during known periods of upstream movement. The study should also determine if upstream passage of sturgeon and striped bass is desirable. Radio tagging is an effective tool for such a study.

SPECIES OF SPECIAL EMPHASIS

The mission of the U.S. Fish and Wildlife Service (FWS) is "to provide Federal leadership in the conservation of fish, wildlife, and their habitat for the continuing benefit of people". In this regard, the Service has completed, through its Regional Offices the annual Regional Resource Planning (RRP process). The RRP process provides an analytical base for decision-making and for communication of these decisions within the FWS and to other agencies and interested publics.

The biological scope of the RRP process encompasses those species for which there are direct or implied FWS authority, and concentrate on those species considered to be key indicators of recognized major problems and opportunities for regional fish and wildlife resource management. The resources in question are designated Species of Special Emphasis (SSE)[1]. Emphasis is on migratory birds, threatened and endangered species, and anadromous fish.

The ACF basin supports fauna considered by the Fish and Wildlife Service to be National Species of Special Emphasis. Within this classification the basin provides life requisite requirements for the following species: American alligator, eastern brown pelican, bald eagle, golden eagle, peregrine falcon, osprey, red-cockaded woodpecker, striped bass, Atlantic sturgeon, black duck, Canada goose, mallard, pintail, wood duck, American woodcock and mourning dove.

ENDANGERED AND THREATENED SPECIES

The Endangered Species Act of 1973 gave the United States one of the most far-reaching laws ever enacted by any country to prevent the extinction of imperiled animals and plants. Under the law, the Secretary of Interior acting through the U.S. Fish and Wildlife Service has the power to protect and conserve all forms of fish, wildlife, and plants that are in serious jeopardy of existence. The primary objective of the FWS is to conserve and restore populations of listed species to a point where they no longer are in danger of extinction and are again self-sustaining members of their ecosystem.

Table 5 identifies Federal and State listed endangered or threatened species that may occur in the ACF River basin. The subsequent narrative discusses the Federally listed species.

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1. Federal Register, Vol. 48, No. 237, December 8, 1983.

Table 4: Endangered and Threatened Species occurring in the ACF Drainage Basin and their Federal and State Status. U.S. Fish and Wildlife Service, 1985c, 1985d; Florida Committee on Rare and Endangered Plants and Animals, 1978a, 1978b, 1978c; Alabama Agricultural Station, 1979, 1984; Georgia Dept. of Natural Resources, 1977a, 1977b.

		Status			
Common Name	Scientific Name	Federal	FL	GA	AL[1]
Florida panther	Felis concolor coryi	E	E	E	E
Gray bat	Myotis grisecens	E	E	E	E
Indiana bat	Myotis sodalis	E	E	E	E
West Indian manatee	Trichechus manatus latirostris	E	E		
Bald eagle	Haliaeetus leucocephalus	E	E	E	E
Arctic peregrine falcon	Falco peregrinus tundrius	T	E	E	T
Red-cockaded woodpecker	Picoides borealis	E	E	E	E
Ivory-billed woodpecker	Campephilus principalis	E	E		
Bachman's warbler	Vermivora bachmanii	E	E	E	E
Wood stork	Mycteria americana	E	E		E
Piping plover	Charadrius melodus	T			
Eastern indigo snake	Drymarchon corais couperi	T	T		T
American alligator	Alligator mississippiensis	E/T[2]	T	E	
Kemp's ridley sea turtle	Lepidochelys kempi	E	E	E	E
Green sea turtle	Chelonia mydas mydas	E/T[3]	E		E
Hawksbill sea turtle	Eretmochelys imbricata	E	E	E	
Leatherback sea turtle	Dermochelys coriacea	E	E	E	
Loggerhead sea turtle	Caretta caretta	T	T		E
Florida torreya	Torreya taxifolia	E		E	
Harper's beauty	Harperocallis flava	E			
Chapman's Rhododendron	Rhododendron chapmanii	E	E		
Canby's dropwort	Coxypolis canbyi	E		T	
Golden eagle	Aquila chrysaetos				T
Snowy plover	Charadrius alexandrinus		T		
Southeastern kestrel	Falco sparverius		T		
Eastern brown pelican	Pelecanus occidentalis carolinensis		T		
Least tern	Sterna albifions		T		
Florida sandhill crane	Grus canadensis pratensis		T		

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		Status			
Common Name	Scientific Name	Federal	FL	GA	AL
Florida black bear	*Ursus americanus floridans*		T		
Bluestripe shiner	*Notropis callitaenia*		T		
Dusky gopher frog	*Rana areolata sevosa*				T
Florida pine snake	*Pituphis melanoleucus mugitus*				T
Barbour's map turtle	*Graptemys barbouri*				T
Gopher tortoise	*Gopherus polyphemus*				T
Amphianthus	*Amphianthus pusillus*			E	
Arabis	*Arabis georgiana*			T	
Bucktorn	*Bumelia thornei*			E	
Indian-plantain	*Cacalia diversifolia*			T	T
Croomia	*Croomia pauciflora*			T	
Pink lady's-slipper	*Cyripedium acaule*			T	
Yellow lady's-slipper	*Cyripedium calceolus* var. *pubescens*			T	
Draba	*Draba aprica*			E	
Fimbristylis	*Fimbristylis perpusilla*			E	
Dwarf witch-alder	*Fothergilla gardenii*			T	
Spider lily	*Hymenocallis coronaria*			E	
Pond-bush	*Litsea aestivalis*			T	
Loosestrife	*Lythrum curtissii*			E	
Water-milfoil	*Myriophyllum laxum*			T	
Cow-bane	*Oxpolis canbyi*			T	
Panic grass	*Panicum hirstii*			E	
Red honeysuckle	*Rhododendrom prunifolium*			T	
Willow	*Salix floridana*			E	
Golden trumpet	*Sarracenia flava*			T	
White-top pitcher plant	*Sarracenia leucophylla*		E	T	
Hooded pitcher plant	*Sarracenia minor*			T	
Parrot pitcher-plant	*Sarracenia psittacina*			T	
Indian pitcher	*Sarracenia purpurea*			E	

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		Status			
Common Name	Scientific Name	Federal	FL	GA	AL
Sweet pitcher-plant	_Sarracenia rubra_			E	
Wild sarsparilla	_Schisandra glabra_			T	
Fringed campion	_Silene polypetala_			E	
False hellebore	_Veratrum woodii_			E	
Pagoda dogwood	_Cornus alternifolia_		T		
Grass-of-parnassus	_Parnassia grandifolia_		E		
Honewort	_Cryptotaenia canadensis_		E		
Dimpled dogtooth-violet	_Erythronium umbilicatum_		T		
Liverlead	_Hepatica americana_		E		
Ashe's magnolia	_Magnolia asheri_		E		
Needle palm	_Rhapidophyllum hystrix_		T		T
Florida yew	_Taxus floridana_		T		
Lance-leaved wake-robin	_Trillium lancifolium_		E		T
Halberd-leaved yellow violet	_Viola hastata_		E		
Sedum	_Sedum pusillum_			T	
Epidendrum	_Epidendrum conopseum_				E
Elliott's croton	_Croton elliotti_				E
Wiregrass	_Gentiana elliottii_				E
Baltzell's sedge	_Carex batlzellii_				T
Coville's rush	_Juncus gymnocarpus_				T
Hypericum	_Hypericum nitidum_				T
Nestronia	_Nestronia umbellula_				T

1. The State of Alabama does not have an official list of endangered and threatened species. Species status indicated on this list is the result of a workshop convened by Alabama Game and Fish in July, 1983 at Auburn University.
2. The alligator is Federally listed as endangered in the State of Alabama and inland Georgia and listed as threatened with Similarity of Appearance in the State of Florida.
3. The green sea turtle is Federally listed as endangered in Florida and threatened in Alabama and Georgia.

The Florida panther's historic range includes all terrestrial habitats in Alabama, Georgia and Florida. Confirmed populations occur in south and south-central Florida. However, there may still be small, scattered populations in other parts of the historic range. It appears the panther needs large wilderness areas with an adequate food supply (deer, hog, turkey, and other small mammals). It is doubtful that the panther would be found in the ACF basin, although further study would be needed to determine this, as large tracts of wilderness do occur (FWS, 1985c, 1986a; FCREPA, 1978a; Georgia DNR, 1977b).

The gray bat's historic and present range includes Alabama, Georgia and Florida and is almost exclusively a cave-dwelling mammal. In the basin, they are known only from caves along the Chipola River in Jackson County, Florida. The gray bat is a nocturnal insectivore and intolerant of human disturbance. The bats utilize only 5 or 6 caves in the entire United States for winter hibernation. The animals form large clusters on the ceilings of the cave and are quite vulnerable to vandalism. After the young are born in early summer, the colony disperses to other caves. Although no critical habitat has been designated for the bat in Jackson County, any project that would cause disturbance to the cave habitat would have an impact on the existing population (FWS, 1985c, 1986a; FCREPA, 1978a; AAES, 1984).

The Indiana bat's historic range includes Florida, Alabama and Georgia. Current range occurs in Alabama and Florida only. The bats utilize limestone caves for winter hibernation, with summer habitat consisting of tree hollows and loose bark on dead trees. They are nocturnal insectivores with the females and juveniles feeding in riparian and forested floodplain areas; males forage over floodplain ridges and hillside forests. In 1955 two specimens were taken at Old Indian Cave, Florida Caverns State Park, adjacent to the Chipola River in Jackson County, Florida. Further study would be needed to determine its present status in the basin (FWS, 1985c, 1986a; FCREPA, 1978a; AAES, 1984).

The West Indian manatee is an aquatic vegetarian mammal inhabiting both salt and freshwater habitats. Historic records suggest the manatee may have occurred from south Florida west to Louisiana on the Gulf coast. In recent years manatees have been sighted in St. Andrew Bay, Bay County, Florida. These sightings are rare and the probability of a manatee occurring in Apalachicola Bay is extremely small (FWS, 1985c, 1986a; FCREPA, 1978a).

The bald eagle's historic and present range includes Alabama, Georgia and Florida. They are sighted yearly around West Point Lake in Troup and Heard Counties, Georgia and occasionally reported during winter on Lake Lanier in Hall County Georgia. They are also known to occur in Seminole, Decatur, Harris, Spalding and Carroll Counties, Georgia. They nest in lower Gulf County and are observed along the Apalachicola River. The bald eagle is primarily riparian, associated with coasts, rivers, and lakes, usually nesting near bodies of water where they feed. Nesting adults usually require large, living tall trees; however they occasionally nest in dead trees. They are opportunistic feeders and will take a variety of vertebrate prey, both living and carrion. Pesticide residues have played a significant role in the decline of bald eagle populations. Other factors that have caused the decline include loss of feeding and nesting sites, human disturbance during nesting period, illegal shooting, loss of nest trees and electrocution from collisions with power lines (FWS 1985c, 1986a; FCREPA, 1978b; AAES, 1984; Georgia DNR, 1977b).

The Arctic peregrine falcon's migration route includes Alabama, Georgia and Florida. The peregrine breeds in the tundra area of Arctic Alaska, Canada and western Greenland and migrates south through eastern and middle North America to the U.S. Gulf coast and then on to middle and South America. Some overwintering occurs along the U.S. Gulf coast. The peregrine diet consists of medium to small birds that are usually hunted and captured in the air. Prey species are usually hunted over open areas such as waterways, swamps, marshes and fields. Pesticide residues, loss of suitable feeding habitat on migration routes or unlawful shooting have played a role in the decline of the peregrine. Additional information and study would be needed to verify the status of this species in the basin (FWS 1985c, 1986a; FCREPA, 1978b; AAES, 1984, Georgia DNR, 1977b).

The red-cockaded woodpecker's historic and present range includes Alabama, Georgia and Florida. The woodpecker occurs above the Fall Line and in southwestern Georgia along counties bordering the Chattahoochee and Flint Rivers (highest population on Fort Benning military reservation, Chattahoochee County) as well as counties adjacent to the Apalachicola River in Florida. The woodpecker typically constructs roost and nest cavities in mature pine trees that are infected with red-heart disease. They are primarily insect feeders. The decline of the woodpecker is attributed primarily to the reduction of pine forest trees sixty years old or older. Within the ACF basin there probably occurs suitable pine forests for the woodpeckers, however, further study of forested habitats in the basin would be needed to verify the status of the species (FWS, 1985c, 1986a; FCREPA, 1978b; AAES, 1984; Georgia DNR, 1977b).

The ivory-billed woodpecker's historic range included southeastern Alabama, extreme southwestern Georgia and the entire State of Florida. Present probable occurrence in the ACF basin would be along the Apalachicola and Chipola Rivers. The woodpecker is thought to require extensive mature stands of lowland hardwood forests without disturbance from cutting. Their diet consists primarily of certain wood boring beetle larvae found in dying or recently dead trees. Fruits, nuts, and seeds form an occasional part of their diet. Decline of the woodpecker has resulted from timber management practices which remove dead or dying trees housing the wood boring insect larvae. Also, general loss of virgin hardwood forests, killing by man as well as being extremely intolerant of human disturbance have contributed toward its demise. Although occurrence is highly unlikely, further study would be needed to verify the existence of the species in the basin (FWS, 1985c, 1986a; FCREPA, 1978b; AAES, 1984; Georgia DNR, 1977b).

Bachman's warbler ranges in the southeastern United States during their breeding season and has been reported only on and near coastal Georgia and southern Florida. They nest in low wet forested areas and thought to feed on insects. Loss of habitat has probably played a significant role in their decline. Although the ACF basin may have suitable habitat it is doubtful that the warbler would occur in the basin (FWS, 1985c, 1986a; FCREPA, 1978b; Georgia DNR, 1977b).

The wood stork's historic breeding range included the southeastern United States. Post-breeding dispersal takes the birds northward through adjacent states. Present breeding range occurs in Florida with one nesting colony just east of the Apalachicola River basin in Leon County. The stork habitat consists of freshwater and brackish wetlands, with nesting occurring primarily in cypress or mangrove swamps, and feeding occurring in freshwater marshes,

flooded pastures and flooded ditches. Fish make up their diet. Decline of the wood stock has resulted primarily from loss of suitable feeding habitats and rookery sites. Further study would be needed to determine if the north Florida colony utilizes the Apalachicola River basin (FWS, 1985c, 1986a; FCREPA, 1978b).

The historic and present wintering range of the piping plover includes the northeastern Gulf coast. The plover breeds on the northern Great Plains, in the Great Lakes, and along the Atlantic coast (to North Carolina). The plovers' major Gulf coast winter concentration periods are from August through October and March through May. Habitat preferences include beaches, and sand flats adjacent to beaches or on coastal inlets. Historically, piping plovers have undergone drastic fluctuations in population numbers. Uncontrolled hunting in the early 1900's brought the species close to extinction. Protective legislation helped birds recover by 1925. Maximum densities were reaches in the 1930's but by 1945 increased recreational use of beaches caused numbers to plunge again; since then, numbers of the plovers continues to decrease. Additional information and study would be needed to verify the status of this species in the basin (FWS, 1985c, 1986a; Haig, 1985).

The eastern indigo snake's present range in the ACF basin includes the lower Apalachicola River basin and southwestern Georgia near Lake Seminole and the Flint and Chattahoochee Rivers. The decline of the species is attributed to a loss of habitat due to such uses as farming, construction, forestry, pasture, etc., and to over-collecting for the pet trade. The snake's large size and docile nature have made it much sought after as a pet. The snake seems to be strongly associated with high, dry, well-drained sandy soils, closely paralleling the sandhill habitat preferred by the gopher tortoise (Gopherus polyphemus). Although during the warmer months, indigos will frequent streams, swamp and occasionally flatwoods. Gopher tortoise burrows and other subterranean cavities are commonly used as dens and egg laying. Indigos reach sexual maturity at 3 to 4 years of age; mating begins in November, peaks in December and continues into March. Food items of the snake include snakes, frog, salamanders, toads, small mammals, birds, and occasionally young turtles. The indigo subdues its prey through the use of its powerful jaws, swallowing the prey, usually still alive. Further study would be needed to determine the status of the snake in the ACF basin (FWS, 1985c, 1986a; Georgia DNR, 1977b; FCREPA, 1978c).

The American alligator's historic and present range includes the lower southeastern United States to Texas and including the Coastal Plains of Alabama, Georgia and Florida. The alligator is found throughout the Apalachicola River basin and along the lower Chattahoochee and Flint River systems. Alligator populations have increased over past years such that they have been Federally delisted to threatened status in coastal Georgia (remain endangered in inland Georgia) and threatened with Similarity of Appearance in Florida. Harvest and sale are permitted in accordance with Federal and State regulations under the status of threatened by Similarity of Appearance. The decline of the alligator has been attributed to excessive exploitation and habitat loss resulting from human encroachment. However, as evidenced by the delisting of the species, restoration of the species is ongoing and exploitation and habitat loss is under control. The alligator does occur within the ACF basin but additional study would be needed for current status in the basin (FWS, 1985c, 1986a; AAES, 1984; Georgia DNR, 1977b; FCREPA, 1978c).

The Kemp's Ridley sea turtle's historic and current range includes Apalachicola Bay and adjacent Gulf of Mexico. Nesting occurs only on approximately 24 km (14.9 mi) of beach in Tamaulipas, Mexico. The adult turtles are restricted to the Gulf of Mexico, and when in shallow coastal and estuarine waters they are often associated with subtropical shorelines of red mangrove. Their diet consists primarily of invertebrates, mostly crabs, but may also include shrimp, snails, sea urchins, sea stars, jellyfish, fish, and occasionally, marine plants. Although a ridley sea turtle may be rarely sighted within or adjacent to the ACF basin, it is highly unlikely that any project action would impact the species (FWS, 1985c, 1986a; FCREP, 1978c).

The green sea turtle's historic and current range includes Apalachicola Bay and adjacent Gulf of Mexico. Nesting in the United States is limited to the east coast of Florida. The turtles are generally found in fairly shallow waters (except when migrating) inside reefs, bays, and inlets. They are attracted to lagoons and shoals with an abundance of marine grass and algae. Their diet consists mainly of marine algae and grasses in shallow waters as well as small mollusks, sponges, crustaceans and jellyfish. Although a green turtle may be rarely sighted within or adjacent to the ACF basin, it is highly unlikely that any project action would impact the species (FWS, 1985c, 1986a; FCREPA, 1978c).

The hawksbill sea turtle's historic and current range includes Apalachicola Bay and adjacent Gulf of Mexico. The turtles frequent rocky areas, reefs, shallow coastal areas, lagoons of oceanic islands and narrow creeks and passes. They are seldom seen in water greater than 19.8 m (65 ft) deep.

Nesting in the United States is limited infrequently to Florida on the Atlantic and southwest coasts. The hawksbill is omnivorous but with a preference to invertebrates. Major cause of decline is exploitation for the shell. Although a turtle may be rarely sighted within or adjacent to the ACF basin, it is highly unlikely any project action would impact the species existence (FWS, 1985c, 1986a; FCREPA, 1978c).

The leatherback sea turtle's historic and current range includes the Gulf of Mexico adjacent to Apalachicola Bay. Rare sightings may occur in shallow estuarine bays, although their major habitat includes open ocean out to the continental shelf. Nesting of any significance occurs on the Atlantic coast of Florida. Their principal food source is jellyfish but also includes sea urchins, squid, crustaceans, tunicates, fish, blue-green algae and floating seaweed. Most likely any projects actions within the ACF basin would not impact the leatherback turtle (FWS, 1985c, 1986a; FCREPA, 1978c).

The loggerhead sea turtle's historic and current range includes the Apalachicola Bay and estuary as well as the adjacent Gulf of Mexico. The loggerhead nests on beaches exhibiting considerable site fixity in returning to the same beach to renest. The loggerhead is known to nest on St. Vincent and both St. George Islands. The mainstay of the turtle's diet are mollusks, crustaceans, fish and other marine animals and plants. Reasons for species decline includes erosion and ocean-front development rendering nesting beaches unsuitable, nest predation, drowning by entrapment in shrimp trawl nets and over-utilization of eggs and meat for food. Any action that would alter or eliminate nesting beaches would impact the sea turtle (FWS, 1985c, 1986a; FCREPA, 1978c).

The Florida torreya's historic and present range appears to have changed little and includes the Apalachicola River basin (Gadsden, Liberty, and Jackson counties) and a site in Decatur County, Georgia. The plant is endemic to the ACF system and is a relatively small conical evergreen, needle-bearing tree. The tree grows on bluffs and ravine slopes in the moist shade of associated pine-hardwoods. The main threat to the plant's existence is a fungal disease, although any habitat alteration would also impact the species (FWS, 1985c, 1986a; FCREPA, 1978d; Georgia DNR, 1977a).

The range for Harper's Beauty has remained essentially the same as when the plant was first discovered in 1965. It has been found at three locations within the Apalachicola National Forest in Franklin and Liberty Counties, Florida. Harper's Beauty is a rhizomatous, perennial herb, with the yellow flower being typical of the lily family. The plant is usually found in open pineland bogs and along moist roadside ditches. The plant's limited range and small numbers make it highly vulnerable to loss. Changes in current land management, accidential loss, vandalism, and/or over collecting could easily lead to extinction of the species (FWS, 1985c, 1986a; FCREPA, 1978d).

Chapman's rhododendron occurs only in Florida in three populations; two occur within the Apalachicola River basin: one in Gulf County and one on the Gadsden-Liberty County line. The plant is an evergreen shrub about two meters tall, the flowers are large and rose in color. It is typically found in the econtonal regions where the drier pine-turkey oak vegetation border on more moist titi (<u>Cyrilla racemiflora</u>) bogs. Logging and drastic site preparation techniques for developing pine plantations have resulted in the loss of habitat for the species. Also, collecting by nursery men and amateur gardeners have threatened the plants existence (FWS, 1985c, 1986a; FCREPA, 1978d).

The Canby's Dropwort's historic and current range includes the southern portion of Georgia. There is currently one known population in each of Lee and Sumter Counties adjacent to the Flint River. The dropwort is a perennial plant growing to 1.2 meters (3.9 feet), and occurs in boggy, low areas. The most significant threat to the species has been through the direct loss or alteration of its wetland habitats. The specie's small numbers also make it vulnerable to potentially harmful losses from unnecessary collecting. Additional study would be needed to verify the species' status in the Flint River basin (FWS, 1986a, 1986b, GA DNR, 1977a).

FEDERAL LAWS PERTAINING TO FISH AND WILDLIFE RESOURCES

The basic authority of the U.S. Fish and Wildlife Service (FWS), Division of Ecological Services evaluation program is the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.). This act specifically states that whenever any body of water is proposed to be impounded, diverted, channelized, or modified in any manner by any department or agency of the United States or by anyone working under a Federal permit or license, such department or agency must first consult with the FWS. The act further states that the purpose of the "consultation" is to conserve wildlife resources by preventing loss of and damage to such resources as well as providing for the development and improvement thereof in connection with such water-resource developments.

In addition, the following laws are considered when evaluating permit applications and/or Federal Projects:

NAME	DESCRIPTION
Fish and Wildlife Act of 1956 (16 U.S.C. 742)(a) 754; 70 Stat. 1119) as amended.	Authorized distribution of information on fish and wildlife; the development of policy and procedure to carry out laws; and conserve, manage and enhance fish and wildlife.
Estuary Protection Act (16 U.S.C. 1221-1226).	Requires the Secretary of Interior to review all project plans for land and water resource development affecting estuaries. Authorizes cost-sharing with States for management of estuaries.
Endangered Species Act of 1973 (16 U.S.C. 1531-1543; 87 Stat. 884) as amended.	Requires that federally listed endangered or threatened species and their critical habitats be protected. Compliance involves conducting species surveys, coordinating with Federal and State agencies, and modifying actions if necessary to avoid impacts on these species.
Federal Water Pollution Control Act Amendments of 1972 (33 U.S.C. 1251-1265, 1281-1292, 1311-1328, 1341-1345, 1361-1376 and other U.S.C. titles; 86 Stat. 816), as amended.	Provides policy, goals, regulations, and funding for Federal, State, and local cooperation in improving and maintaining the quality of the Nation's water resources. Provides penalties.
Anadromous Fish Conservation Act (16 U.S.C. 757a-757b; 79 Stat. 1125), as amended.	Provides for cooperative agreements with States and other non Federal interests for conservation development and enhancement of anadromous fish.
National Environmental Policy Act of 1969 (42 U.S.C. 4321-4347; 83 Stat. 582).	Provides National policy to encourage harmony between man and his environment. Prevents damage to environment and enriches the understanding of the environment. Requires all Federal agencies to prepare Environmental Impact Statements for public and other agencies review.
Marine Protection, Research and Sanctuaries Act of 1972 (16 U.S.C. 1431-1434, 33 U.S.C. Stat. 1401-1444; 86 Stat. 1052) as amended.	Regulates dumping of materials into ocean waters. Establishes programs to determine long term effects of pollution overfishing. Authorized designation of marine sanctuaries.

There are numerous other laws that also pertain to fish and wildlife. While they may not, on a continuous basis, directly relate to project evaluations, they play a part in the conservation of this Nation's fish and wildlife resources.

NAME	DESCRIPTION
Bald Eagle Protection Act of 1940 (16 U.S.C. 668-668d; 54 Stat. 250), as amended.	Regulations protection bald and golden eagles. Provides penalties and cooperative management agreements with States.
Black Bass Act (16 U.S.C. 851-856; 44 Stat. 576) as amended.	Regulations for interstate transportation of captured or caught fish. Provides penalties.
Flood Control Act of 1944 (16 U.S.C. 460d, 825s.) as amended and supplemented.	Authorizes Corps to construct, maintain, and operate public park and recreation facilities at water development projects and provides permitting system for local interests (State and local) to do the same (grant leases to them).
Sikes Act (16 U.S.C. 670a-670o; 74 Stat. 1052) as amended.	Provides a mechanism for cooperative planning for fish and wildlife conservation on military reservations. Also provides for recreation planning.
Federal-Aid Highways of 1968 (23 U.S.C. 101 et. seq. and other U.S.C. Titles; 82 Stat. 815), as amended.	National policy that, in highway planning and construction, special effort be made to preserve the natural beauty of country, public parks, recreation lands, wildlife refuges, and historical sites. Provides for cooperation and consultation with the Secretary of Housing and Urban Development, the Interior, and Agriculture and with States.
Federal Aid in Fish Restoration Act (16 U.S.C. 777-777k; 64 Stat. 430), as amended (Dingle-Johnson Act) 1950.	Provides policy, regulations, and funding for Federal-State cooperation in wildlife conservation and management. Funding for investigation, projects, and their administration.
Migratory Bird Hunting and Conservation (16 U.S.C. 718-718h; 48 State. 452), as amended. (Duck Stamp Act)	Provides for the sale of the duck stamp (permit for hunting migratory birds). Furnishes funds to be used for acquisition of refuges and waterfowl production areas (wetlands).
Migratory Game and Insectivorous Birds Protection Act (16 U.S.C.; 31 Stat. 187), as amended.	Regulations for preservation of migratory and insectivorous birds. Provides penalties.
Migratory Bird Treaty Act of 1918 (U.S.C. 703-711; 40 Stat. 755). as amended.	Provides for cooperation with Canada and Mexico in the preservation of migratory birds and international transport of these birds or parts thereof. Provides penalties.
Federal Aid in Wildlife Restoration Act (16 U.S.C. 669-669i; 50 Stat. 917) as amended. (Pittman-Robertson Act).	Provides policy, regulations, and funding for Federal-State cooperation. Provides funding for investigations, projects, and their administrations.

NAME	DESCRIPTION
Federal Environmental Pesticide Control Act of 1972 (7 U.S.C. 136-1364; 86 Stat. 975) as amended.	Regulation and control of pesticides and their use.
Federal Power Act (16 U.S.C. 791a-825r; 41 Stat. 1063), as amended.	Regulations and control of hydroelectric power generation, all power transmission, and oil and gas transmission. Must consider fish and wildlife.
Wild and Scenic Rivers Act of 1968 (16 U.S.C. 1271-1287; 82 Stat. 906, as amended).	Provides policy, criteria, and methods through which selected rivers which possess outstandingly remarkable scenic, recreational geologic, fish and wildlife, historic cultural, or other values are to be preserved in a free-flowing state. Rivers shall be protected for benefit of present and future generations. Provides that other components may be added. Prescribes State participation and methods of funding for acquisitions and development.
Land and Water Conservation Fund Act of 1965 (16 U.S.C. 460 1-4-460 1-11; 78 Stat. 897), as amended.	Provides mechanism for grants-in-aid to be used by State and Federal agencies for acquisition and development of outdoor recreation land.
National Trails System Act (16 U.S.C. 1241-1249; 82 Stat. 919), as amended.	Provides mechanisim for planning and acquiring a National Trail System--primarily near urban centers. Designates criteria for recreation scenic, historic, natural and cultural trails.
National Wildlife Refuge System Administration Act of 1966 (16 U.S.C. 668dd-668ee; 80 Stat. 927) as amended	Consolidates authority for acquisition and development of lands administered as refuges and production areas for the protection and conservation of fish and wildlife. Provides for public use. Provides regulations and penalties.
Animal Damage Control Act of 1931 (7 U.S.C. 426-416b; 46 Stat. 1468).	Provides for research and control of named animals to protect domestic stock, suppress rabies and tularemia, and protect agriculture, horticulture, and forestry.
Recreational Use of Fish and Wildlife Conservation Areas Act (16 U.S.C. 406K-460k-4; 76 Stat. 653), as amended.	Provides recreational opportunity on or adjacent to fish and wildlife lands, provided the recreation is consistent with the primary purpose of the lands. Can accept gifts of land.
Rivers and Harbors Act of 1899 (33 U.S.C. 401 et. seq., 30 Stat. 1151) as amended and supplemented.	Prohibits dumping of refuse in navigable waters and placing of structures in navigable waters. Provides a permitting system for both. Provides coordination with other Federal and State agencies.

NAME	DESCRIPTION
Refuge Revenue-Sharing Act (16 U.S.C. 715*s; 49 Stat. 383), as amended.	Provides for revenue sharing between National Wildlife Refuge system and State and local governments. Revenues come from sale of animals, timber, hay, grass, soil, minerals, sand, or gravel or from leases for grazing, public accommodations, or facilities.
Water Bank Act (16 U.S.C. 1301-1311; 84 Stat. 1468)	Provides monetary incentives to farmers to preserve, restore, and improve wetlands and reduce water runoff and soil erosion. Requires a conservation agreement to receive funds. Also provides for consultation with Secretary.
Coastal Zone Management Act of 1972 (16 U.S.C. 1451-1464; 86 Stat. 1280), as amended.	Assists States in developing land and water use programs for the coastal zone. Directs consultation and cooperation with other Federal agencies. Concurrence of Secretary of Interior a requirement.
Fishery Conservation and Management Act of 1976 (16 U.S.C. 1801-1802, 1811-1813, 1821-1826, 1851-1862, 1882, 90 Stat. 331).	Establishes Regional Fishery Management Councils to cover 200-mile fishery conservation zone. Also extends Federal Marine Mammal jurisdiction to the same zone.
Lacey Act of 1900 (16 U.S.C. 701, 702, 31 Stat. 187, 32 Stat. 285), as amended; criminal code provisions (18 U.S.C. 42-44; 62 Stat. 687), as amended.	Provides authority to preserve, distribute, introduce and restore game birds and other wild birds in those parts of the United States where they have become scarce or extinct.
Federal Water Project Recreation Act (16 U.S.C. 4601-12-4601-21; 79 Stat. 213), as amended.	Provides for consideration and enhancement of fish and wildlife and recreation in the planning and construction of any water development project. Encourages non-Federal administration of project lands for such purposes. Other projects purposes must be coordinated with these.
Migratory Bird Conservation Act (16 U.S.C. 715 et. seq. 45 Stat. 1222)	Provides authorization for acquisition and formation of fish and game refuges, production areas, etc.
Toxic Substances Control Act (15 U.S.C. 2601-2619; 90 Stat. 2003).	Establishes program for testing and regarding commerce of hazardous chemicals. Coordination and consultation with other Federal agencies required.

NAME	DESCRIPTION
Marine Mammal Protection Act of 1972 (16 U.S.C. 1361, 1362, 1371-1384, 1401-1407; 86 Stat. 1027) as amended.	Establishes Federal responsibility for conservation of marine mammals, Interior and Commerce Departments have specified groups of mammals to protect. A marine mammal commission was established to take part in research and regulations.
Environmental Education Act of 1975 (16 U.S.C. 3011-3018; 84 Stat. 1312), as amended.	Established Office of Environmental Education. Provides grants and technical assistance to institutions, agencies and organizations.
Watershed Protection and Flood Prevention Act (16 U.S.C. 1001-1009; 33 U.S.C. 701b; 68 Stat. 666) as amended.	Assistance to local organizations in carrying out works to prevent erosion, floodwater and and sediment damages in small watersheds. Section 12 allows the Secretary of Interior to assist.

Finally, executive orders provide additional support to existing fish and wildlife related laws:

Executive Order 11988 Floodplain Management (May 24, 1977).	Floodplain management considered when evaluating water or land use plans. Only allows development when agencies have considered alternatives to avoid adverse effects and incompatible development, or modified actions minimize harm within the floodplain.
Executive Order 11987 Exotic Organisms (May 24, 1977).	Restricts unlawful introduction of exotic species on Federal lands and encourages States and private citizens to do the same. Only allows importation of exotic species within lawful limits, and forbids use of Federal funds for such action.
Executive Order 12322 Water Resources Projects (September 17, 1981).	Ensures efficient and coordinated planning and review of projects. Plans must be reviewed by OMB prior to being submitted to congress by action agencies. Plan must be consistent with President's Policy and Program. Principles and Standards (45 F.R. 64366), and other applicable laws and regulations.
Executive Order 11990 Protection of Wetlands (May 24, 1977).	Minimizes the destruction, loss or degradation of wetlands; preserves and enhances the natural and beneficial values of wetlands. Only allows development projects if no practical alternatives can be ascertained and if the proposal includes all practical measures to minimize harm to wetlands.

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Appendix 1: Definitions of State of Georgia Water Use Classification and Water Quality Standards 391-3-6-.03.

(1) Purpose. The establishment of water quality standards.

(2) Water Quality Enhancement:

(a) The purposes and intent of the State in establishing Water Quality Standards are to provide enhancement of water quality and prevention of pollution; to protect the public health or welfare in accordance with the public interest for drinking water supplies, conservation of fish, game and other beneficial aquatic life, and agricultural, industrial, recreational, and other beneficial uses.

(b) Those waters in the State whose existing quality is better than the minimum levels established in standards on the date standards become effective will be maintained at high quality; with the State having the power to authorize new developments, when applicable to intrastate and interstate waters of Georgia it has been affirmatively demonstrated to the State that a change is justifiable to provide necessary social or economic development; and provided further that the level of treatment required is the highest and best practicable under existing technology to protect existing beneficial water uses.

(c) In applying these policies and requirements, the State of Georgia will recognize and protect the interest of the Federal Government in interstate (including coastal and estuarine) waters. Toward this end the State will consult and cooperate with the Environmental Protection Agency on all matters affecting the Federal interest.

(3) Definitions. All terms used in this Paragraph shall be interpreted in accordance with definitions as set forth in the Act and as otherwise herein defined:

(a) "Reasonable and necessary uses" means drinking water supplies, conservation of fish, game and other aquatic life, agricultural, industrial, recreational, and other legitimate uses.

(b) "Shellfish" refers to clams, oysters, scallops, mussels, and other mollusks.

(c) "Intake temperature" is the natural or background temperature of a particular waterbody unaffected by any man-made discharge or thermal input.

(d) "Coastal waters" are those littoral recreational waters on the ocean side of the Georgia coast.

(4) Water Use Classifications. Water use classifications for which the criteria of the Paragraph are applicable are as follows:

(a) Drinking Water Supplies

(b) Recreation

(c) Fishing, Propagation of Fish, Shellfish, Game and Other Aquatic Life

(d) Agricultural

(e) Industrial

(f) Navigation

(g) Wild River

(h) Scenic River

(i) Urban Stream

(5) General Criteria for All Waters. The following criteria are deemed to be necessary and applicable to all waters of the State:

(a) All waters shall be free from materials associated with municipal or domestic sewage, industrial waste or any other waste which will settle to form sludge deposits that become putrescent, unsightly or otherwise objectionable.

(b) All waters shall be free from oil, scum and floating debris associated with municipal or domestic sewage, industrial waste or other discharges in amounts sufficient to be unsightly or to interfere with legitimate water uses.

(c) All waters shall be free from material related to municipal, industrial or other discharges which produce turbidity, color, odor or other objectionable conditions which interfere with legitimate water uses.

(d) All waters shall be free from toxic, corrosive, acidic and caustic substances discharged from municipalities, industries or other sources in amounts, concentrations or combinations which are harmful to humans, animals or aquatic life.

(e) Applicable State and Federal requirements and regulations for the discharge of radioactive substances shall be met at all times.

(f) No man-made physical or other alteration of stream beds that may violate established water quality standards, or reduce the waste assimilative capacity of the streams, will be permitted without the expressed approval of the Environmental Protection Division.

(6) Specific Criteria for Classified Water Usage. The following criteria are deemed necessary and shall be required for the specific water usage as shown:

(a) Drinking Water Supplies:

1. Those waters approved by the Environmental Protection

Division and requiring only approved disinfection and meeting the requirements of the Federal Drinking Water Standards; or waters approved by the Environmental Protection Division for human consumption and food-processing or for any other use requiring water of a lower quality:

(i) Bacteria: Fecal coliform not to exceed a geometric mean of 50 per 100 ml based on at least four samples taken over a 30-day period and not to exceed 200 per 100 ml in more than five percent of the samples in any 90-day period.

(ii) Floating solids, settleable solids, sludge deposits or any taste, odor or color producing substances: None associated with any waste discharge.

(iii) Sewage, industrial or other wates: None.

2. Those raw water supplies requiring approved treatment to meet the requirements of the Environmental Protection Division and the Federal Drinking Water Standards or which are approved by the Environmental Protection Division for human consumption and food-processing; or for any other use requiring water of a lower quality:

(i) Bacteria: Fecal coliform not to exceed a geometric mean of 1,000 per 100 ml based on at least four samples taken over a 30-day period and not to exceed a maximum of 4,000 per 100 ml.

(ii) Dissolved Oxygen: A daily average of 6.0 mg 1 and no less than 5.0 mg 1 at all times for waters designated as trout streams by the State Game and Fish Division. A daily average of 5.0 mg 1 and no less than 4.0 mg 1 at all times for water supporting warm water species of fish.

(iii) pH: Within the range of 6.0 - 8.5.

(iv) No material or substance in such concentration that, after treatment, would exceed the requirements of the Environmental Protection Division and the latest edition of Federal Drinking Water Standards.

(v) Temperature: Not to exceed 90° F. At no time is the temperature of the receiving waters to be increased more than 5° F above intake temperature except that in estuarine waters the increase will not be more than 1.5° F. In streams designated as trout or smallmouth bass waters by the State Game and Fish Division, there shall be no elevation or depression of natural stream temperature.

(c) Fishing, Propagation of Fish, Shellfish, Game and Other Aquatic Life; or for any other use requiring water of a lower quality:

1. Dissolved Oxygen: A daily average of 6.0 mg/l and no less than 5.0 mg/l at all times for waters designated as trout streams

by the State Game and Fish Division. A daily average of 5.0 mg/l and no less than 4.0 mg/l at all times for waters supporting warm water species of fish.

2. pH: Within the range of 6.0 - 8.5.

3. Bacteria: Fecal coliform not to exceed a geometric mean of 1,000 per 100 ml based on at least four samples taken over a 30-day period and not exceed a maximum of 4,000 per 100 ml.

4. Bacteria: (Applicable only to waters designated as approved shellfish harvesting waters by the appropriate State agencies) The requirements will be consistent with those established by the State and Federal agencies responsible for the National Shellfish Sanitation Program.

5. Temperature: Not to exceed 90° F. At no time is the temperature of the receiving waters to be increased more than 5° F above intake temperature except that in estuarine waters the increase will not be more than 1.5° F. In streams designated as trout or smallmouth bass waters by the State Game and Fish Division, there shall be no elevation or depression of natural stream temperatures.

~~wildlife in and on the body of water into which the discharge is to be made and such demonstration has not been rebutted. It is the intent of the Commission that to the extent practicable, proceedings under this provision should be conducted jointly with proceedings before the federal government under Section 316(a), Public Law 92-500.~~

~~(ii) Zones of mixing for blowdown discharges from recirculated cooling water systems, and for discharges from non-recirculated cooling water systems of existing sources, shall be established on the basis of the physical and biological characteristics of the RBW.~~

~~(iii) When a zone of mixing is established pursuant to this Subsection 17-3.05(1)(f), F.A.C., any otherwise applicable temperature limitations contained in Section 17-3.05(1), F.A.C., shall be met at its boundary; however, the Department may also establish maximum numerical temperature limits to be measured at the POD and to be used in lieu of the general temperature limits in section 17-3.05(1), F.A.C., to determine compliance by the discharge with the established mixing zone and the temperature limits in Section 17-3.05(1), F.A.C.~~

~~Specific Authority: 403.061, 403.062, 403.087, 403.504, 403.704, 403.804, F.S.~~
~~Law Implemented: 403.021, 403.061, 403.087, 403.088, 403.141, 403.161, 403.182, 403.502, 403.702, 403.708, F.S.~~
~~History: Formerly 28-5.02, 17-3.02, Amended 10-28-70, Amended and Renumbered 3-1-79.~~

17-3.051 Minimum Criteria for Surface Waters. All surface waters of the State shall at all places and at all times be free from:

(1) Domestic, industrial, agricultural, or other man-induced non-thermal components of discharges which, alone or in combination with other substances or in combination with other components of discharges (whether thermal or non-thermal):

(a) Settle to form putrescent deposits or otherwise create a nuisance; or

(b) Float as debris, scum, oil, or other matter in such amounts as to form nuisances; or

(c) Produce color, odor, taste, turbidity, or other conditions in such degree as to create a nuisance; or

(d) Are acutely toxic; or

(e) Are present in concentrations which are carcinogenic, mutagenic, or teratogenic to human beings or to significant, locally occurring, wildlife or aquatic species; or

(f) Pose a serious danger to the public health, safety, or welfare.

(2) Thermal components of discharges which, alone, or in combination with other discharges or components of discharges (whether thermal or non-thermal):

(a) Produce conditions so as to create a nuisance; or

(b) Do not comply with applicable provisions of Subsection 17-3.05(1), F.A.C.

Specific Authority: 403.061, 403.062, 403.087, 403.504, 403.704, 403.804, F.S.
Law Implemented: 403.021, 403.061, 403.087, 403.088, 403.141, 403.161, 403.182, 403.502, 403.702, 403.708, F.S.
History: Formerly 28-5.02, 17-3.02, Amended 10-28-78, Amended and Renumbered 3-1-79, Amended 1-1-83.

17-3.06 Classification of Waters, Usage.
Specific Authority: 403.061. F.S. Law Implemented: 403.021, 403.031, 403.061, 403.101(1), F.S. History: Formerly 28.506, Amended and Renumbered as 17-3.081, 3-1-79.

17-3.061 Surface Waters: General Criteria.

(1) The criteria of surface water quality hereinafter provided shall be applied to all surface waters except within zones of mixing.

(2) A violation of any of the following surface water quality criteria constitutes pollution. Additional, more stringent or alternative criteria than indicated in this paragraph may, however, be specified for individual classes of water under Sections 17-3.091, 17-3.111, 17-3.121, 17-3.131, and 17-3.141 of this Chapter.

(a) Arsenic - shall not exceed 0.05 milligrams per liter.

(b) BOD - shall not be increased to exceed values which would cause dissolved oxygen to be depressed below the limit established for each class and, in no case shall it be great enough to produce nuisance conditions.

(c) Chlorides - in predominantly marine waters, the chloride content shall not be increased more than ten percent (10%) above normal background chloride content. Normal daily and seasonal fluctuations in chloride levels shall be maintained.

(d) Chromium - shall not exceed 0.50 milligrams per liter hexavalent or 1.0 milligrams per liter total chromium in effluent discharge and shall not exceed 0.05 milligrams per liter total chromium after reasonable mixing in the receiving water.

(e) Copper - shall not exceed 0.5 milligrams per liter.

(f) Detergents - shall not exceed 0.5 milligrams per liter.

(g) Dissolved Oxygen -

1. Notwithstanding the specific numerical criteria applicable to individual classes of water, dissolved oxygen levels that are attributable to natural background conditions or man-induced conditions which cannot be controlled or abated may be established as alternative dissolved oxygen criteria for a water body or portion of a water body.

2. Alternative dissolved oxygen criteria may be established by the Secretary or a District Manager in conjunction with the issuance of a permit or other Department action only after public notice and opportunity for public hearing. The determination of alternative criteria shall be based on consideration of the factors described in Section 17-3.031(2)(a)-(d), F.A.C.

3. Alternative criteria shall not result in a lowering of dissolved oxygen levels in the water body, water body segment or any adjacent waters,

and shall not violate the minimum criteria specified in Section 17-3.051, F.A.C. Daily and seasonal fluctuations in dissolved oxygen levels shall be maintained.

(h) Fluorides - shall not exceed 10.0 milligrams per liter as fluoride ion.

(i) Lead - shall not exceed 0.05 milligrams per liter.

(j) Nutrients - The discharge of nutrients shall continue to be limited as needed to prevent violations of other standards contained in this Chapter. Man-induced nutrient enrichment (total nitrogen or total phosphorus) shall be considered degradation in relation to the provisions of Section 17-3.041 and Section 17-4.242, F.A.C.

(k) Oils and Greases:

1. Dissolved or emulsified oils and greases shall not exceed 5.0 milligrams per liter.

2. No undissolved oil, or visible oil defined as iridescence, shall be present so as to cause taste or odor, or otherwise interfere with the beneficial use of waters.

(l) pH - shall not vary more than one unit above or below natural background provided that the pH is not lowered to less than 6 units or raised above 8.5 units. If natural background is less than 6 units, the pH shall not vary below natural background or vary more than one unit above natural background. If natural background is higher than 8.5 units, the pH shall not vary above natural background or vary more than one unit below background.

(m) Phenolic compounds as listed - Chlorinated phenols including trichlorophenols; chlorinated creosols; 2-chlorophenol; 2, 4 dichlorophenol and pentachlorophenol; 2, 4-dinitrophenol; phenol - shall not exceed 1.0 micrograms per liter unless higher values are shown not to be chronically toxic. Such higher values shall be approved in writing by the Secretary. Phenolic compounds other than those produced by the natural decay of plant material, listed or unlisted, shall not taint the flesh of edible, fish or shellfish or produce objectionable taste or odor in a drinking water supply.

(n) Radioactive Substances:

1. Combined radium 226 and 228 - shall not exceed five picocuries per liter.

2. Gross alpha particle activity including radium 226, but excluding radon and uranium - shall not exceed fifteen picocuries per liter.

(o) Specific Conductance - shall not be increased more than 100% above background levels or to a maximum level of 500 micromhos per centimeter in surface waters in which the specific conductance of the water at the surface is less than 500 micromhos per centimeter; and shall not be increased more than 50% above background level or to a maximum level of 5,000 micromhos per centimeter in surface waters in which the specific conductance of the water at the surface is equal to or greater than 500 micromhos per centimeter but less than 5,000 micromhos per centimeter.

(p) Substances in concentrations which injure, are chronically toxic to,

or produce adverse physiological or behavioral response in humans, animals, or plants - none shall be present.

(q) Substances in concentrations which result in the dominance of nuisance species - none shall be present.

(r) Turbidity - shall not exceed 29 Nephelometric Turbidity Units (NTU's) above natural background.

(s) Zinc - shall not exceed 1.0 milligrams per liter.

Specific Authority: 403.061, 403.062, 403.087, 403.504, 403.704, 403.804, F.S. Law Implemented: 403.021, 403.061, 403.087, 403.088, 403.141, 403.161, 403.181, 403.502, 403.702, 403.708, F.S.
History: Formerly 17-3.05(1) and (2), Amended 2-12-75, 8-26-75, 6-10-76, Amended and Renumbered 3-1-79, Amended 10-2-80, 2-1-83.

17-3.07 Criteria: Class I Waters - Public Water Supply.
Specific Authority: 403.061, F.S. Law Implemented: 403.021, 403.031, 403.061, 403.101, F.S. History: Formerly 28-5.07, Amended 7-3-73, Amended and Renumbered as 17-3.091, 3-1-79.

17-3.071 Groundwaters: General Criteria.
Specific Authority: 403.061, 403.062, 403.087, 403.504, 403.704, 403.804, F.S. Law Implemented: 403.021, 403.061, 403.087, 403.088, 403.141, 403.161, 403.182, 403.502, 403.702, 403.708, F.S. History: New 3-1-79, Amended 12-27-79, 1-12-81, 1-19-82, Amended and Renumbered as 17-3.401, 1-1-83.

17-3.08 Criteria: Class II Waters-Shellfish Propagation and Harvesting.
Specific Authority: 403.061, F.S. Law Implemented: 403.021, 403.031, 403.061, 403.101, F.S. History: Formerly 28-5.08, Amended 6-10-72, 8-30-72, 7-3-73, Amended and Renumbered as 17-3.111, 3-1-79.

17-3.081 Classification of Surface Waters, Usage, Reclassification.

(1) All surface waters of the State have been classified according to designated uses as follows:

CLASS I	Potable Water Supplies
CLASS II	Shellfish Propagation or Harvesting
CLASS III	Recreation, Propagation and Maintenance of a Healthy, Well-Balanced Population of Fish and Wildlife
CLASS IV	Agricultural Water Supplies
CLASS V	Navigation, Utility and Industrial Use

(2) Classification of a water body according to a particular designated use or uses does not preclude use of the water for other purposes.

(3) The specific water quality criteria corresponding to each surface water classification are listed in Sections 17-3.091 to 17-3.141, F.A.C., inclusive.

(4) Water quality classifications are arranged in order of the degree of

protection required, with Class I water having generally the most stringent water quality criteria and Class V the least. However, Class I, II, and III surface waters share water quality criteria established to protect recreation and the propagation and maintenance of a healthy, well-balanced population of fish and wildlife.

(5) Criteria applicable to a classification are designed to maintain the minimum conditions necessary to assure the suitability of water for the designated use of the classification. In addition, applicable criteria are generally adequate to maintain minimum conditions required for the designated uses of less stringently regulated classifications. Therefore, unless clearly inconsistent with the criteria applicable, the designated uses of less stringently regulated classifications shall be deemed to be included within the designated uses of more stringently regulated classifications.

(6) Any person regulated by the Department or having a substantial interest in this Chapter may seek reclassification of waters of the State by filing a petition with the Secretary in the form required by Section 17-1.24, F.A.C.

(7) A petition for reclassification shall reference and be accompanied by the information necessary to support the affirmative finding required in this Section to support the proposed reclassification.

(8) All reclassifications of waters of the State shall be adopted, after public notice and public hearing, only upon an affirmative finding by the Environmental Regulation Commission that:

(a) The proposed reclassification will establish the present and future most beneficial use of the waters; and

(b) Such a reclassification is clearly in the public interest.

(9) Reclassification of waters of the State which establishes more stringent criteria than presently established by this Chapter shall be adopted, only upon additional affirmative finding by the Environmental Regulation Commission that the proposed designated use is attainable, upon consideration of environmental, technological, social, economic, and institutional factors.

Specific Authority: 403.061, 403.087, 403.088, 403.804, F.S.
Law Implemented: 403.021, 403.061, 403.087, 403.088, 403.141, 403.161, 403.182, 403.502, 403.504, 403.702, 403.708, F.S.
History: Formerly 28-5.06, 17-3.06, Amended and Renumbered 3-1-79, Amended 1-1-83, 2-1-83.

17-3.09 Criteria: Class III Waters - Recreation - Propagation and Management of Fish and Wildlife.
Specific Authority: 403.061, F.S. Law Implemented: 403.021, 403.031, 403.061, 403.101, F.S. History: Formerly 28-5.09, Amended 6-10-72, 8-30-72, 7-3-73, Amended and Renumbered as 17-3.121, 3-1-79.

17-3.091 Criteria: Class I Waters - Potable Water Supplies. The criteria listed below are for surface waters designated for use as a potable

supply. The standards contained in Sections 17-3.051 and 17-3.061, F.A.C., shall apply to all waters of this class, unless more stringent levels are specified below. The following criteria are to be applied except within zones of mixing:

(1) Alkalinity - shall not be depressed below 20 milligrams per liter as $CaCO_3$.

(2) Ammonia (un-ionized) - shall not exceed 0.02 milligrams per liter.

(3) Bacteriological Quality - Coliform group shall not exceed 1,000 per 100 milliliters as a monthly average, using either most probable number (MPN) or membrane filter (MF) counts; nor exceed 1,000 per 100 milliliters in more than 20% of the samples examined during any month; nor exceed 2,400 per 100 milliliters (MPN or MF count) at any time. Based on a minimum of five samples taken over a 30-day period, the fecal coliform bacterial level shall not exceed 200 per 100 milliliters as computed by the log mean, nor shall more than 10% of the total samples taken during any 30-day period exceed 400 per 100 milliliters.

(4) Barium - shall not exceed 1 milligram per liter.

(5) Beryllium - shall not exceed 0.011 milligrams per liter in waters with a hardness equal to or less than 150 (in milligrams per liter of $CaCO_3$), and shall not exceed 1.10 milligrams per liter in harder waters.

(6) Biological Integrity - the Shannon-Weaver diversity index of benthic macroinvertebrates shall not be reduced to less than 75% of background levels as measured using organisms retained by a U.S. Standard No. 30 sieve and collected and composited from a minimum of three Hester-Dendy type artificial substrate samplers of 0.10 to 0.15 square meters area each, incubated for a period of four weeks.

(7) Cadmium - shall not exceed 0.8 micrograms per liter in a water with a hardness (in milligrams per liter of $CaCO_3$) equal to or less than 150, and shall not exceed 1.2 micrograms per liter in harder waters.

(8) Chlorides - shall not exceed two hundred fifty (250) milligrams per liter.

(9) Chlorine (total residual) - shall not exceed 0.01 milligrams per liter.

(10) Copper - shall not exceed 30 micrograms per liter.

(11) Cyanide - shall not exceed 5.0 micrograms per liter.

(12) Dissolved Oxygen - shall not be less than 5 milligrams per liter. Normal daily and seasonal fluctuations above this level shall be maintained.

(13) Dissolved Solids - not to exceed five hundred (500) milligrams per liter as a monthly average or exceed one thousand (1,000) milligrams per liter at any time.

(14) Fluorides - shall not exceed 1.5 milligrams per liter.

(15) Iron - shall not exceed 0.3 milligrams per liter.

(16) Lead - shall not exceed .03 milligrams per liter.

(17) Mercury - shall not exceed 0.2 micrograms per liter.

(18) Nickel - shall not exceed 0.1 milligrams per liter.

(19) Nitrate - shall not exceed 10 milligrams per liter as N or that concentration determined in (21) below.

(20) Nutrients - In no case shall nutrient concentrations of a body of water be altered so as to cause an imbalance in natural populations of aquatic flora or fauna.

(21) Pesticides and Herbicides:

(a) Aldrin plus Dieldrin - shall not exceed 0.003 micrograms per liter.

(b) Chlordane - shall not exceed 0.01 micrograms per liter.

(c) 2-4-D - shall not exceed 100 micrograms per liter.

(d) 2,4,5-TP - shall not exceed 10 micrograms per liter.

(e) DDT - shall not exceed 0.001 micrograms per liter.

(f) Demeton - shall not exceed 0.1 micrograms per liter.

(g) Endosulfan - shall not exceed 0.003 micrograms per liter.

(h) Endrin - shall not exceed 0.004 micrograms per liter.

(i) Guthion - shall not exceed 0.01 micrograms per liter.

(j) Heptachlor - shall not exceed 0.001 micrograms per liter.

(k) Lindane - shall not exceed 0.01 micrograms per liter.

(l) Malathion - shall not exceed 0.1 micrograms per liter.

(m) Methoxychlor - shall not exceed 0.03 micrograms per liter.

(n) Mirex - shall not exceed 0.001 micrograms per liter.

(o) Parathion - shall not exceed 0.04 micrograms per liter.

(p) Toxaphene - shall not exceed 0.005 micrograms per liter.

(22) Phthalate Esters - shall not exceed 3.0 micrograms per liter.

(23) Polychlorinated Biphenyls - shall not exceed 0.001 micrograms per liter.

(24) Selenium - shall not exceed 0.01 milligrams per liter.

(25) Silver - shall not exceed 0.07 micrograms per liter.

(26) Total Dissolved Gases - shall not exceed 110% of the saturation value for gases at the existing atmospheric and hydrostatic pressure.

(27) Transparency - the depth of the compensation point for photosynthetic activity shall not be reduced by more than 10% as compared to the natural background value.

(28) Zinc - shall not exceed 0.03 milligrams per liter.

Specific Authority: 403.061, 403.062, 403.087, 403.504, 403.704, 403.804, F.S. Law Implemented: 403.021, 403.061, 403.087, 403.088, 403.141, 403.161, 403.182, 403.502, 403.702, 403.708, F.S.
History: Formerly 28-5.07, 17-3.07, Amended 7-3-73, Amended and Renumbered 3-1-79, Amended 1-1-83, 2-1-83.

17-3.10 Criteria: Class IV Waters-Agricultural and Industrial Water Supply.
Specific Authority: 403.061, F.S. Law Implemented: 403.021, 403.031, 403.061, 403.101, F.S. History: Formerly 28-5.10, Amended 6-10-72, 8-30-72, Amended and Renumbered as 17-3.131, 3-1-79.

17-3.101 Criteria: Class I-B Waters - Potable and Agricultural Water Supplies and Storage - Groundwaters.
Specific Authority: 403.061, 403.062, 403.087, 403.504, 403.704, 403.804, F.S. Law Implemented: 403.021, 403.061, 403.087, 403.088, 403.141, 403.161, 403.182, 403.502, 403.702, 403.708, F.S. History: New 3-1-79, Amended and Renumbered as 17-3.404, 1-1-83.

17-3.11 Criteria: Class V Waters-Navigation, Utility, and Industrial Use.
Specific Authority: 403.061, F.S. Law Implemented: 403.021, 403.031, 403.061, 403.101, F.S. History: Formerly 28-5.11, Amended and Renumbered as 17-3.141, 3-1-79.

17-3.111 Criteria: Class II Waters-Shellfish Propagation or Harvesting. The criteria listed below are for surface waters classified as Class II. The standards contained in Section 17-3.051 and 17-3.061, F.A.C., also shall apply to all waters of this class, unless additional or more stringent levels are specified below. The following criteria are to be applied except within zones of mixing:

(1) Aluminum - shall not exceed 1.5 milligrams per liter.

(2) Antimony - shall not exceed 0.2 milligrams per liter.

(3) Bacteriological Quality - the median coliform MPN (Most Probable Number) of water shall not exceed seventy (70) per hundred (100) milliliters, and not more than ten percent (10%) of the samples shall exceed a MPN of two hundred and thirty (230) per one hundred (100) milliliters. The fecal coliform bacterial level shall not exceed a median value of 14 MPN per 100 milliliters with not more than ten percent (10%) of the samples exceeding 43 MPN per 100 milliliters.

(4) Biological Integrity - the Shannon-Weaver diversity index of benthic macroinvertebrates shall not be reduced to less than 75% of established background levels as measured using organisms retained by a U.S. Standard No. 30 sieve and collected and composited from a minimum of three natural substrate samples, taken with Ponar type samplers with minimum sampling areas of 225 square centimeters.

(5) Bromine and Bromates - free (molecular) bromine shall not exceed 0.1 milligrams per liter, and bromates shall not exceed 100 milligrams per liter.

(6) Cadmium - shall not exceed 5.0 micrograms per liter.

(7) Chlorine (total residual) - shall not exceed 0.01 milligrams per liter.

(8) Copper - shall not exceed 0.015 milligrams per liter.

(9) Cyanide - shall not exceed 5.0 micrograms per liter.

(10) Dissolved Oxygen - the concentration in all waters shall not average less than 5 milligrams per liter in a 24-hour period and shall never be less than 4 milligrams per liter. Normal daily and seasonal fluctuations above these levels shall be maintained.

(11) Fluorides - shall not exceed 1.5 milligrams per liter.

(12) Iron - shall not exceed 0.3 milligrams per liter.

(13) Manganese - shall not exceed 0.1 milligrams per liter.

(14) Mercury - shall not exceed 0.1 micrograms per liter.

(15) Nickel - shall not exceed 0.1 milligrams per liter.

(16) Nutrients - In no case shall nutrient concentrations of a body of water be altered so as to cause an imbalance in natural populations of aquatic flora or fauna.

(17) Odor - threshold odor number shall not exceed 24 at 60°C as a daily average.

(18) Pesticides and Herbicides:

(a) Aldrin plus Dieldrin - shall not exceed 0.003 micrograms per liter.

(b) Chlordane - shall not exceed 0.004 micrograms per liter.

(c) DDT - shall not exceed 0.001 micrograms per liter.

(d) Demeton - shall not exceed 0.1 micrograms per liter.

(e) Endosulfan - shall not exceed 0.001 micrograms per liter.

(f) Endrin - shall not exceed 0.004 micrograms per liter.

(g) Guthion - shall not exceed 0.01 micrograms per liter.

(h) Heptachlor - shall not exceed 0.001 micrograms per liter.

(i) Lindane - shall not exceed 0.004 micrograms per liter.

(j) Malathion - shall not exceed 0.1 micrograms per liter.

(k) Methoxychlor - shall not exceed 0.03 micrograms per liter.

(l) Mirex - shall not exceed 0.001 micrograms per liter.

(m) Parathion - shall not exceed 0.04 micrograms per liter.

(n) Toxaphene - shall not exceed 0.005 micrograms per liter.

(19) pH - shall not vary more than one unit above or below natural background of coastal waters as defined in 17-3.05(1)(c), F.A.C., or more than two-tenths unit above or below natural background of open waters as defined in 17-3.05(1)(c), F.A.C., provided that the pH is not lowered to less than 6.5 units or raised above 8.5 units. If natural background is less than 6.5 units, the pH shall not vary below natural background or vary more than one unit above natural background for coastal waters or more than two-tenths unit above natural background for open waters. If natural background is higher than 8.5 units, the pH shall not vary above natural background or vary more than one unit below natural background of coastal waters or more than two-tenths unit below natural background of open waters.

(20) Phosphorus (elemental) - shall not exceed 0.1 micrograms per liter.

(21) Polychlorinated Biphenyls - shall not exceed 0.001 micrograms per liter.

(22) Selenium - shall not exceed 0.025 milligrams per liter.

(23) Silver - shall not exceed 0.05 micrograms per liter.

(24) Total Dissolved Gases - shall not exceed 110% of the saturation value for gases at the existing atmospheric and hydrostatic pressures.

(25) Transparency - the depth of the compensation point for photosynthetic activity shall not be reduced by more than 10% as compared to the natural background value.

Specific Authority: 403.061, 403.062, 403.087, 403.504, 403.704, 403.804, F.S.
Law Implemented: 403.021, 403.061, 403.087, 403.088, 403.141, 403.161, 403.182, 403.502, 403.702, 403.708, F.S.
History: Formerly 28-5.08, 17-3.08, Amended 6-10-72, 8-30-72, 7-3-73, Amended and Renumbered 3-1-79, Amended 2-1-83.

17-3.12 Definitions.
Specific Authority: 403.061, F.S. Law Implemented: 403.021, 403.031, 403.061, 403.101, F.S. History: Formerly 28-5.12, Amended and Renumbered as 17-3.021, 3-1-79.

17-3.121 Criteria: Class III Waters-Recreation-Propagation and Maintenance of a Healthy, Well-Balanced Population of Fish and Wildlife. The criteria listed below are for surface waters classified as Class III. The standards contained in Sections 17-3.051 and 17-3.061, F.A.C., also apply to all waters of this classification unless additional or more stringent criteria are specified below. The following criteria are to be applied except within zones of mixing.

(1) Alkalinity - shall not be depressed below 20 milligrams per liter as $CaCO_3$ in predominantly fresh waters.

(2) Aluminum - shall not exceed 1.5 milligrams per liter in predominantly marine waters.

(3) Ammonia (un-ionized) - shall not exceed 0.02 milligrams per liter in predominantly fresh waters.

(4) Antimony - shall not exceed 0.2 milligrams per liter in predominantly marine waters.

(5) Bacteriological Quality - fecal coliform bacteria shall not exceed a monthly average of 200 per 100 ml of sample, nor exceed 400 per 100 ml of sample in 10 percent of the samples, nor exceed 800 per 100 ml on any one day, nor exceed a total coliform bacteria count of 1,000 per 100 ml as a monthly average, nor exceed 1,000 per 100 ml in more than 20 percent of the samples examined during any month, nor exceed 2,400 per 100 ml at any time. Monthly averages shall be expressed as geometric means based on a minimum of 10 samples taken over a 30 day period. Either MPN or MF counts may be utilized.

(6) Beryllium - in predominantly fresh waters shall not exceed 0.011 milligrams per liter in waters with a hardness equal to or less than 150 (in milligrams per liter of $CaCO_3$) and shall not exceed 1.10 milligrams per liter in harder waters.

(7) Biological Integrity - the Shannon-Weaver diversity index of benthic macroinvertebrates shall not be reduced to less than 75 percent of established background levels as measured using organisms retained by a U.S. Standard No. 30 sieve and, in predominantly fresh waters, collected and composited from a minimum of three Hester-Dendy type artificial substrate samplers of 0.10 to 0.15 m^2 area each, incubated for a period of four weeks; and, in predominantly marine waters, collected and composited from a minimum of three

natural substrate samples, taken with Ponar type samplers with minimum sampling area of 225 square centimeters.

(8) Bromine and Bromates - free (molecular) bromine shall not exceed 0.1 milligrams per liter in predominantly marine waters, and bromates shall not exceed 100 milligrams per liter in predominantly marine waters.

(9) Cadmium - shall not exceed 5.0 micrograms per liter in predominantly marine waters; shall not exceed 0.8 micrograms per liter in predominantly fresh waters in water with a hardness (in milligrams per liter of $CaCO_3$) of less than 150, and shall not exceed 1.2 micrograms per liter in harder waters.

(10) Chlorine (total residual) - shall not exceed 0.01 milligrams per liter.

(11) Copper - shall not exceed .015 milligrams per liter in predominantly marine waters; shall not exceed .03 milligrams per liter in predominantly fresh waters.

(12) Cyanide - shall not exceed 5.0 micrograms per liter.

(13) Dissolved Oxygen - in predominantly fresh waters, the concentration shall not be less than 5 milligrams per liter. In predominantly marine waters, the concentration shall not average less than 5 milligrams per liter in a 24-hour period and shall never be less than 4 milligrams per liter. Normal daily and seasonal fluctuations above these levels shall be maintained in both predominantly fresh waters and predominantly marine waters.

(14) Fluorides - shall not exceed 5.0 milligrams per liter in predominantly marine waters.

(15) Iron - shall not exceed 1.0 milligrams per liter in predominantly fresh waters; 0.3 milligrams per liter in predominantly marine waters.

(16) Lead - shall not exceed .03 milligrams per liter in predominantly fresh waters.

(17) Mercury - shall not exceed 0.1 micrograms per liter in predominantly marine waters; shall not exceed 0.2 micrograms per liter in predominantly fresh waters.

(18) Nickel - shall not exceed 0.1 milligrams per liter.

(19) Nutrients - In no case shall nutrient concentrations of a body of water be altered so as to cause an imbalance in natural populations of aquatic flora or fauna.

(20) Pesticides and Herbicides:

(a) Aldrin plus Dieldrin - shall not exceed 0.003 micrograms per liter.

(b) Chlordane - shall not exceed 0.01 micrograms per liter in predominantly fresh waters and shall not exceed 0.004 micrograms per liter in predominantly marine waters.

(c) DDT - shall not exceed 0.001 micrograms per liter.

(d) Demeton - shall not exceed 0.1 micrograms per liter.

(e) Endosulfan - shall not exceed 0.003 micrograms per liter in predominantly fresh waters and shall not exceed 0.001 micrograms per liter in predominantly marine waters.

(f) Endrin - shall not exceed 0.004 micrograms per liter.

(g) Guthion - shall not exceed 0.01 micrograms per liter.

(h) Heptachlor - shall not exceed 0.001 micrograms per liter.

(i) Lindane - shall not exceed 0.01 micrograms per liter in predominantly fresh waters and shall not exceed 0.004 micrograms per liter in predominantly marine waters.

(j) Malathion - shall not exceed 0.1 micrograms per liter.

(k) Methoxychlor - shall not exceed 0.03 micrograms per liter.

(l) Myrex - shall not exceed 0.001 micrograms per liter.

(m) Parathion - shall not exceed 0.04 micrograms per liter.

(n) Toxaphene - shall not exceed 0.005 micrograms per liter.

(21) pH - shall not vary more than one unit above or below natural background of predominantly fresh waters and coastal waters as defined in 17-3.05(1)(c), F.A.C., or more than two-tenths unit above or below natural background of open waters as defined in 17-3.05(1)(c), F.A.C., provided that the pH is not lowered to less than 6 units in predominately fresh waters, or less than 6.5 units in predominately marine waters, or raised above 8.5 units. If natural background is less than 6 units, in predominately fresh waters or 6.5 units in predominately marine waters, the pH shall not vary below natural background or vary more than one unit above natural background of predominately fresh waters and coastal waters, or more than two-tenths unit above natural background of open waters. If natural background is higher than 8.5 units, the pH shall not vary above natural background or vary more than one unit below natural background of predominately fresh waters and coastal waters, or more than two-tenths unit below natural background of open waters.

(22) Phosphorus (elemental) - shall not exceed 0.1 micrograms per liter in predominantly marine waters.

(23) Phthalate Esters - shall not exceed 3.0 micrograms per liter in predominantly fresh waters.

(24) Polychlorinated Biphenyls - shall not exceed 0.001 micrograms per liter.

(25) Selenium - shall not exceed 0.025 milligrams per liter.

(26) Silver - shall not exceed 0.07 micrograms per liter in predominantly fresh waters and 0.05 micrograms per liter in predominantly marine waters.

(27) Total Dissolved Gases - shall not exceed 110% of the saturation value for gases at the existing atmospheric and hydrostatic pressures.

(28) Transparency - the depth of the compensation point for photosynthetic activity shall not be reduced by more than 10% compared to the natural background value.

(29) Zinc - shall not exceed .03 milligrams per liter in predominantly fresh waters.

Specific Authority: 403.061, 403.062, 403.087, 403.504, 403.704, 403.804, F.S. Law Implemented: 403.021, 403.061, 403.087, 403.088, 403.141, 403.161, 403.182, 403.502, 403.702, 403.708, F.S.
History: Formerly 28-5.09, 17-3.09, Amended 6-10-72, 8-30-72, 7-3-73, Amended and Renumbered 3-1-79, Amended 2-1-83.